

Richard Cousley

The Orthodontic Mini-implant Clinical Handbook



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The Orthodontic Mini-implant Clinical Handbook

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Preface

If I have seen further than others, it is by standing upon the shoulders of giants.

Sir Isaac Newton (1642–1727)

Most of this book has been written only five miles from Woolsthorpe Manor, the location of both Sir Isaac Newton's birth and the orchard where the fabled apple's fall to the ground signified his theory of gravity. Like Sir Isaac, I wish to acknowledge that my achievements (albeit on a much simpler level) have only been possible because of the huge intellectual and practical advances of mini-implant researchers in countries as diverse as Korea, Japan, Denmark, Germany, the USA, Brazil and Turkey. These pioneers have ensured that 21st century orthodontics benefits from a powerful and versatile new adjunct: the orthodontic mini-implant (also known as mini-screw, mini-screw implant, micro-implant or temporary anchorage device [TAD]). For the first time, orthodontists are able to reliably control anchorage and tooth movements in all three dimensions.

Consequently, orthodontic mini-implants have begun to change clinical practice around the world and their use is widely regarded as representing a paradigm shift in clinical orthodontics. They provide independent, stable, low compliance anchorage in routine cases, and for complex cases their use significantly expands the range of problems which can be effectively treated by orthodontics. Furthermore, observations of novel clinical effects have begun to confirm or alter long held views on orthodontic biomechanics and dentoalveolar remodelling.

Despite such wide ranging innovations, many 'grass-root' orthodontists have yet to embrace this new technique of anchorage reinforcement: why is this? Is it because of high cost, surgical invasiveness,

poor patient acceptance, limited clinical applications, or a lack of published research? Fortunately the answer to all of these concerns is a resounding 'no'. Whilst it is relatively early for many prospective clinical trials to have been conducted and published, large numbers of biological science and clinical research papers already provide a sound evidence base. In particular, the mini-implant, not headgear, now represents the gold standard for anchorage. Equally, many orthodontists have found mini-implants to be minimally invasive, safe, reliable, well tolerated, cost effective and highly useful in multiple clinical scenarios. Instead, the slow adoption of this new technology by some clinicians appears to be due to a combination of unfounded safety worries (especially regarding damage to the roots), clinical inertia, scepticism and even apathy. In reality, it is easier to try out (and conduct research trials on) a new type of orthodontic bracket than it is to adopt a fundamentally new clinical technique. I had elements of this mindset when mini-implants first became available in the UK in 2003. However, my own clinical experience and numerous detailed contributions to the worldwide literature (summarised in Chapter Two) have since convinced me that mini-implants will cause fundamental and irreversible changes in orthodontic practice in terms of both routine anchorage reinforcement and wide-ranging, even face-changing, clinical applications.

This book aims to provide orthodontists with the essential theoretical and clinical mini-implant information to enable them to easily introduce skeletal anchorage into their clinical practice in a wide variety of common clinical scenarios (especially in conjunction with straight wire appliances). It is also intended as a reference for dental and surgical colleagues who may receive requests to insert orthodontic mini-implants.

P R E F A C E

This handbook is not intended to replace larger mini-implant textbooks, which readers may find useful for further background details and examples of unusual clinical scenarios. General principles are covered in the initial chapters then subsequent chapters focus on a step-by-step approach (with clinical tips and, where necessary, laboratory descriptions) to guide the novice through the most common clinical uses for orthodontic mini-implants. Whilst this entails a degree of repetition, the over-arching concept is that the essential clinical information for each scenario is easily available in one area of text. Notably the techniques described are not intended to represent the only ways of using mini-implants, but rather the culmination of my learning curve and accumulated knowledge such that new orthodontists may feel confident in using mini-implants from the outset.

The clinical chapters in this handbook have a 'cookbook' feel, although this has both positive and negative connotations in the era of evidence based medicine. I strongly believe that clinicians should have a sound understanding of the principles and basis for techniques such as mini-implant usage. However, the experience of providing mini-implant courses has taught me that colleagues with limited experience or confidence with mini-implants have a justifiable need for basic clinical guidelines based on the best available practice and evidence. Consequently this book is structured so that readers may easily follow the main steps for a specific clinical scenario whilst learning the key benefits of mini-implant anchorage. I hope that both you and your patients benefit accordingly.

Richard R.J. Cousley

Mini-implant Principles and Potential Complications

The origins of orthodontic bone anchorage

Orthodontic-specific skeletal fixtures were developed from two distinct sources:

- restorative implants
- maxillofacial surgical plating kits.¹

Orthodontic implants were first produced in the 1990s by modification of dental implant designs, making them shorter (e.g. 4–6 mm length) and wider (e.g. 3 mm diameter). However, they retained the crucial requirement for osseointegration, i.e. a direct structural and functional union of bone with the implant surface causing clinical ankylosis of the fixture. In contrast, mini-plates and mini-implants (mini-screws) are derived from bone fixation technology, and primarily rely on mechanical retention rather than osseointegration. In effect, modification of the maxillofacial bone plate design, adding a transmucosal neck and intra-oral head, resulted in the mini-plate; whilst adaption of the fixation screw design produced the mini-implant. Since the start of this millennium a wide variety of customised orthodontic mini-implants have been produced and these are now used in the vast majority of orthodontic bone anchorage applications. Orthodontic implants are no longer in standard use and the invasive nature of mini-plates appears to limit their use to orthopaedic traction (e.g. Class III) cases.

Using the right terminology

Unfortunately a misleading array of terms has been used for bone anchorage devices and their applications in both journals and the commercial literature. Essentially it is best to encompass all types of fixtures which provide skeletal anchorage under the umbrella

terms: Bone Anchorage Devices (BADs) or Temporary Anchorage Devices (TADs), although the latter term does not indicate the essential role of bone in this anchorage. This book covers only one of the three types of BADs: mini-implants. Whilst the terms mini-implant and mini-screw are used interchangeably in the literature, it is erroneous to use the terms micro-screws or micro-implants since these fixtures are small (mini) and not *microscopic*. I prefer the term mini-implant since it conveys the small size and implantable nature of these temporary fixtures.

Second, there appears to be much misunderstanding over whether mini-implants osseointegrate. Most mini-implants are made from either titanium or titanium alloy and histological studies show variable levels of bone–implant contact (BIC).^{2,3} However, it is misleading to refer to this as osseointegration. Rather, clinical usage and percussion indicate that mini-implants are mechanically retained (like bone fixation screws) rather than forming a clinically discernible ankylotic union with the bone (which occurs with restorative implants secondary to the initial BIC phase). Hence, mini-implants can be immediately loaded and easily unscrew, usually without anaesthetic, at any time after insertion. This may be because of their relatively smooth surface and possibly because the surface contact is more a physical phenomenon than a biochemical one.

Mini-implants are mechanically retained (like bone fixation screws) rather than forming a clinically discernible ankylotic union with the bone.

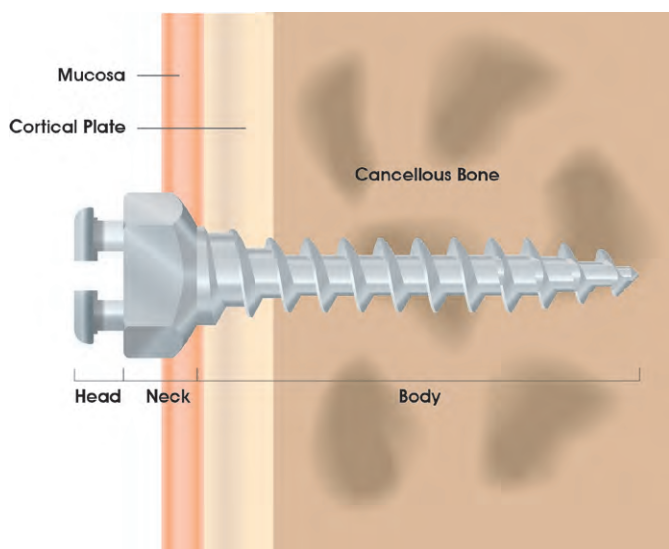


Figure 1.1 Diagram showing the three principal sections of a mini-implant: the head superficial to the tissues, the neck traversing the mucosa, and the threaded body within the cortical and cancellous bone.

Principal design features

Most mini-implants have three constituent parts: the head, neck and body (Fig. 1.1), and are fabricated from a titanium alloy such as surgical grade five (Ti-6Al-4V). The head is the platform which connects to orthodontic appliances or elastic traction. The neck is the part that traverses the mucosa. The body is the endosseous section with threads around a core and a tapered tip. Mini-implants were initially available only in self-tapping (non-drilling) forms whereby a full depth pilot hole had to be drilled before mini-implant insertion. However, many self-drilling screws are now available. These have a tapered body shape with sharp tips and threads, and are inserted in a corkscrew-like manner. Full depth pre-drilling is avoided, although shallow perforation of the cortex is still advantageous where the cortex is thick or dense, e.g. the posterior mandible and palate.

Clinical indications for mini-implants

Mini-implant usage may be broadly divided according to the case application and form of anchorage.

Routine cases

- Cases with high anchorage demands, e.g. retraction of prominent upper incisors or centreline correction (especially where unilateral anchorage only is required). Orthodontists new to mini-implant usage

may find it easiest to introduce them into their clinical practice in such cases since the other aspects of the treatment are usually uncomplicated, enabling the orthodontist to readily recognise the anchorage effects and gain experience.

- Adults and older adolescents who wouldn't comply well with other anchorage options, especially headgear.
- Where extrusive tooth movements would be unfavourable (risking an anterior openbite or vertical excess).

Complex cases

- Where conventional biomechanics would be limited, e.g. molar intrusion to correct an anterior openbite.
- Where conventional dental anchorage is limited by an inadequate number of anchor teeth (due to tooth loss or hypodontia) or periodontal support.

Direct and indirect anchorage

- Direct loading is when traction is applied from the mini-implant's head to an appliance, typically with elastic chain or nickel titanium (NiTi) coil springs (Fig. 1.2a).
- Indirect loading involves using the mini-implant to reinforce anchor teeth, from which traction is applied (Figs 1.2b,c). Whilst indirect anchorage avoids some potential biomechanical side-effects (as discussed in Chapter Three) it risks insidious anchorage loss through flexing of the intermediary wire and undetected tipping or bodily translation of the mini-implant. Consequently, I prefer to use direct anchorage wherever possible and this will be elucidated in the clinical scenario chapters.

Potential mini-implant complications

A number of risks and side-effects have been observed with mini-implant clinical usage and in the research literature. Fortunately, these are reversible in most clinical situations, but it is important to consider them in an effort to maximise success and to provide informed patient consent.

Root/periodontal damage

Multiple clinical and animal studies have shown that traumatised root surfaces are repaired within 12 weeks by cellular cementum and periodontal regeneration (provided that there is no infection portal present).^{4,5,6,7,8,9,10,11} Orthodontists can be reassured that there are no known reports of tooth ankylosis or loss arising from mini-implant usage. This may be

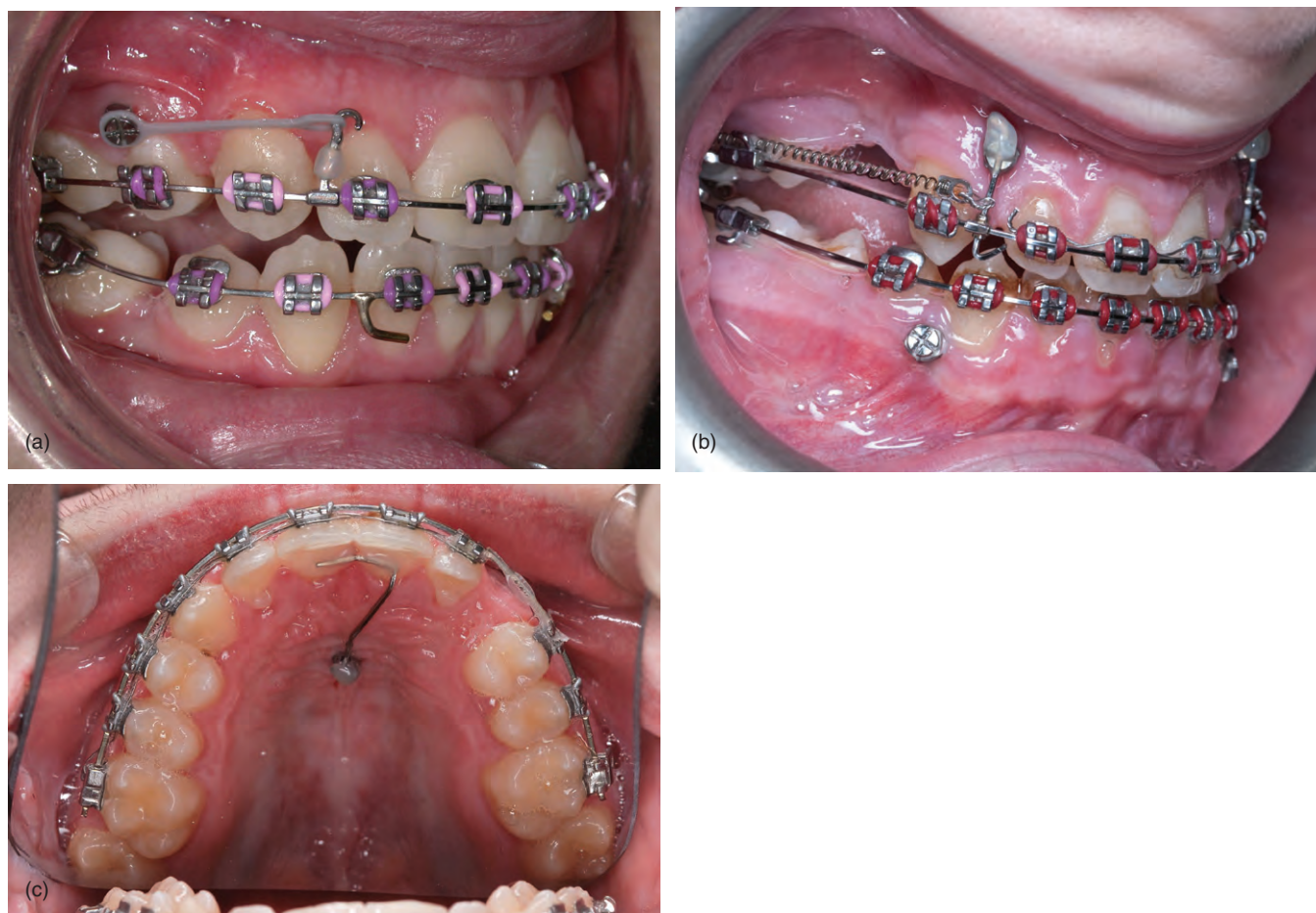


Figure 1.2 (a) Direct anchorage where this grey elastomeric attachment provides traction from the mini-implant head to a powerarm on the fixed appliance for en masse retraction of the anterior teeth. (b) The maxillary mini-implant provides indirect anchorage for molar protraction in this hypodontia case. Horizontal traction is applied, using a NiTi coil spring, connected to a vertical auxiliary wire, which in turn is joined to both the main archwire (using a cross-tube attachment) and the mini-implant head (where its position is secured by composite resin). (c) Indirect anchorage of the upper incisors during unilateral molar protraction, using an elastomeric chain on the fixed appliance. This involves a 0.019 × 0.025 stainless steel auxiliary wire from the mid-palatal mini-implant's head to the central incisors' palatal surfaces, secured to both with composite resin.

because, in normal clinical usage, if a self-drilling mini-implant contacts a root then the insertion stalls and its tip is highly likely to blunt, preventing extensive penetration of the root tissues. Indeed, the patient is likely to complain of pain even before root contact. Therefore, any irreversible effect from mini-implant and tooth proximity is on the mini-implant: it fails (by becoming mobile) *not* the tooth.^{12,13,14,15}

Any irreversible effect from mini-implant–tooth proximity is on the mini-implant: it fails (by becoming mobile) *not* the tooth.

Mini-implant failure

- Primary failure occurs when a mini-implant is clinically mobile at the time of insertion. This is due to inadequate cortical bone support in terms of its thickness and density, or close mini-implant proximity to an adjacent tooth root.^{12,16,17}
- Secondary failure refers to a situation where the mini-implant is initially stable but then exhibits mobility, usually after 1–2 months. This delayed instability is due to bone necrosis around the mini-implant threads, which may result from thermal bone damage (during pilot drilling), excessive insertion torque, excessively close proximity to a tooth root, traction overload, or a combination of these.

Perforation of nasal and maxillary sinus floors

There is no evidence that this is problematic in terms of either infection or creation of a fistula. Indeed, the consensus based on dental implant research is that a soft tissue lining forms over a perforating fixture's end. However, in order to maximise bone engagement and minimise patient discomfort it is generally recommended that maxillary alveolar insertion sites should be within 8mm of the alveolar crest in dentate areas, and closer where maxillary molars are absent.

Damage to neurovascular tissues

Disruption of the inferior dental, mental or greater palatine nerves and blood vessels is highly unlikely given their relative distance from standard insertion sites. The nasopalatine nerve is closer to potential anterior palatal insertion sites, but this can be readily avoided if recommended mid-palatal insertion procedures are followed, e.g. mid-palatal insertion sites ought to be distal to the transverse level of the maxillary canines.

Mini-implant fracture

Fracture, especially of the tip section, may occur when a root is inadvertently contacted and/or the insertion angle is altered with the mini-implant partially inserted into the cortical plate. Fractures of the main portion of a mini-implant body, on either insertion or removal, appear to be a particular risk with mini-implants featuring a narrow diameter and cylindrical body design (Fig. 1.3),^{18,19} or when excessive insertion torque



Figure 1.3 Intra-oral radiograph of the retained fractured part of a cylindrically shaped mini-implant situated mesial to the maxillary first molar.

occurs (e.g. in the posterior mandible with dense, thick cortical bone). In the rare event that removal of a fractured part is indicated then this involves creating access by raising a small mucoperiosteal flap, trephination of a narrow collar of bone around the mini-implant end, and then derotation of the fractured fragment using a weingarts or mosquitos-like instrument.

Pain

There is often an expectation that high levels of pain will occur, but the opposite is true, such that some patients appear to feel virtually no discomfort during and after insertion.^{20,21} The majority of patients appear to experience mild pressure-related pain at the time of insertion and up to 24 hours of low level pain thereafter. This is self-limiting, controlled by simple analgesics (e.g. paracetamol or ibuprofen) and comparable (but of shorter duration) to other orthodontic experiences, such as the effects of separators and aligning archwires.²² The latter comparison is beneficial when it comes to explaining the likely pain experience to patients who already have a fixed appliance in situ. When it comes to mini-implant removal, local anaesthesia is usually not required and indeed patients find that the injection sensation is worse than the actual discomfort of explantation.²³

The majority of patients appear to experience mild pressure-related pain at the time of insertion.

Soft tissue problems

The labial or buccal mucosa adjacent to a mini-implant head may be traumatised especially if the mini-implant has a prominent profile, or sharp edges, or it is inserted in or near loose mucosa (Fig. 1.4). Peri-implant inflammation, analogous to gingivitis around the mini-implant neck, is usually superficial and self-limiting. It is more likely if the mini-implant is either over-inserted in attached gingiva or inserted in an area of mobile mucosa. If tissue hyperplasia fails to resolve with oral hygiene measures, and either interferes with



Figure 1.4 Labial ulceration caused by this mandibular mini-implant's insertion at the mucogingival junction and by the active movement of the adjacent labial sulcus.



Figure 1.5 (a) Hyperplasia of the palatal mucosa covering an over-inserted mini-implant in the palatal alveolar site between the left molars. (b) Normal tissue appearance after simple excision of the hyperplastic tissue and replacement of this mini-implant. Minor peri-implant hyperplasia is seen on the right side.

use of the mini-implant or causes patient discomfort, then the mini-implant should be removed (Fig. 1.5). Fortunately, acute infections are rarely seen and are readily resolved by antibiotics or immediate explantation.

Mini-implant migration

This depends on the head (and neck) to body ratio, on the degree of bone support, and the relative force level. In effect, both self-tapping and self-drilling mini-implants may tip and/or translate bodily in the direction of the applied force.^{24,25, 26,27,28} This is problematic if it causes the mini-implant head to approximate an adjacent bracket or crown and cause soft tissue impingement or difficulty in utilising the mini-implant head.

On balance, the risk–benefit relationship for mini-implants appears to be highly favourable for patients with high or atypical anchorage requirements. This means that the consent process (discussed in Chapter Five) should focus on tangible limitations, such as mini-implant instability and pain, rather than on more theoretical risks of tissue damage.

Biomechanical side-effects

In many respects conventional fixed appliances often only exhibit subtle biomechanical side-effects such as frictional binding, tooth tipping and anchorage loss, because these effects are usually localised to single teeth or a group of several teeth. For example, traction applied at the coronal level (to a bracket) may result in tipping and poorly controlled bodily movement of that tooth. Since the adjunctive use of mini-implants provides more profound anchorage, active in all three dimensions and extrinsic to the fixed appliance, the side-effects may also be more strongly expressed and affect the entire arch (when continuous arch mechanics are utilised). Two clear examples of this occur when oblique traction is applied directly from a mini-implant to retract a canine, using traction applied to the canine bracket on either a flexible or rigid archwire. The oblique vector of traction encourages the canine to tip distally causing either a flexible archwire to exhibit a 'rollercoaster' bowing phenomenon (Fig. 1.6a), or a rigid archwire to rotate the entire arch (around its centre of rotation) causing a combination of molar intrusion and incisor extrusion (Fig. 1.6b).

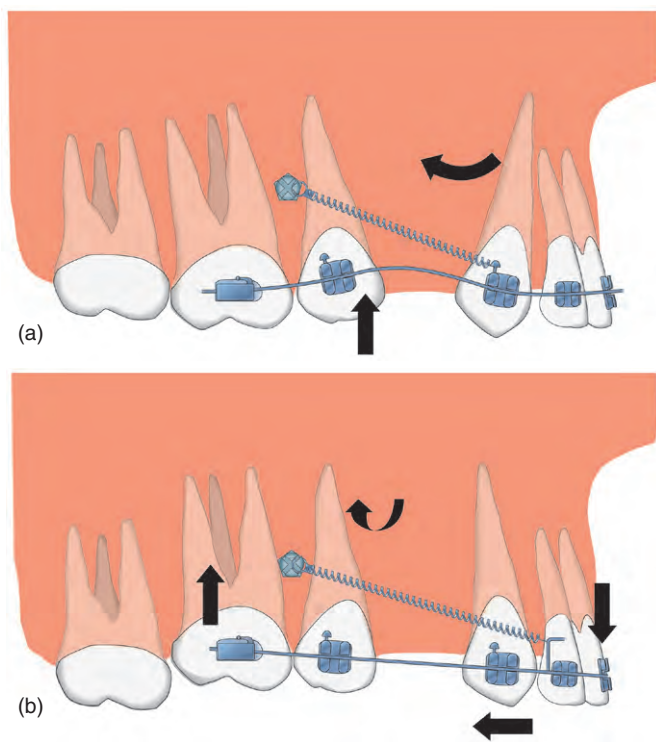


Figure 1.6 Diagrams showing the vertical side-effects of an oblique vector of traction from a buccal mini-implant to the anterior teeth on (a) flexible and (b) rigid archwires. Distal tipping of the canine and a rollercoaster bowing of the archwire occurs in scenario (a), whilst predominantly molar intrusion occurs in (b).

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Maximising Mini-implant Success: Clinical Factors

A large number of research papers have been published in the orthodontic (and to a lesser extent in the surgical and dental implant) literature at an ever-increasing rate since the start of this millennium. This collective evidence provides a sound basis for mini-implant usage, although it may be difficult for orthodontists and dental colleagues to keep track of all this new information. Consequently, this chapter aims to collate and summarise the essential findings of the most relevant scientific and clinical research papers, in order that orthodontists may both understand and maximise their clinical usage of mini-implants.

Overall success rates

Mini-implant success is generally defined as the fixture remaining stable under continuous orthodontic loading for a minimum of 6 months, although many papers use a year as the minimum term. There is a consensus in the present literature that the success rate varies according to anatomical sites, e.g. 80 and 90% for the mandible and maxilla respectively.^{1,2,3,4,5,6,7,8,9,10,11,12} This seems counter-intuitive since the mandible is generally regarded as the stronger jaw bone, but the reasons for this paradox will be explained here. Interestingly, mini-implants with minor mobility may still be graded as successful. This is evident clinically by slight rotational or lateral movement of the mini-implant on manipulation. This is painless and consequently asymptomatic for the patient. It is easily resolved by tightening the mini-implant, usually by one half to a full clockwise rotational (insertional) turn, provided that this

does not submerge the head, and without the need for anaesthesia. When the mini-implant displays obvious lateral mobility with light digital pressure then this indicates failure and the mini-implant should be removed. Fortunately, most mini-implant failures become clinically evident within the first few months of insertion,^{4,8,9} enabling early replacement or a modification to the treatment plan. Conversely, when a mini-implant feels firm after two months in situ then normal orthodontic forces may be applied with confidence.

Most mini-implant failures become clinically evident within the first few months of insertion enabling early replacement.

Factors affecting mini-implant success

These are generally subdivided into three categories: patient, mini-implant and technique factors, and will be discussed accordingly.

Patient factors

Whilst mini-implant success appears to be unaffected by patient gender, the antero-posterior skeletal relationship, dental crowding, periodontal and temporomandibular status, several factors clearly affect stability. Their basis and clinical consequences are summarised below.

Cortical bone thickness and density

A combination of clinical, animal and artificial bone studies has demonstrated that the most important patient determinants of primary stability are the density and thickness of the maxillary and mandibular cortical plates. This helps to explain the variations seen in clinical studies of mini-implant success rates where both anatomical sites and individuals differ in terms of the cortical bone layer's quantity and quality.¹³ The key facts to consider are:

- Cortical depth typically ranges from 1 to 2 mm and generally increases towards the apical aspect of the alveolus. In the maxillary alveolus cortical depth peaks both mesial and distal to the canines (the canine eminence) and the first molars, which partly accounts for the frequent use of these sites for anterior and posterior anchorage points, respectively. The maxillary alveolar cortex is thicker on the palatal than the buccal side, which contributes to the value of palatal alveolar insertions in anterior openbite correction (discussed in Chapter Nine), and the highest alveolar values for both jaws occur in mandibular molar sites.^{14,15,16,17,18,19,20,21}
- An increase in either the cortical thickness or density leads to an increase in insertion torque (the resistance to rotational insertion).^{22,23,24,25,26,27,28} Thickness and density are co-dependent factors with density appearing to be the more influential factor in terms of mini-implant primary stability.^{24,25} The density of the underlying cancellous bone is much less relevant, except where the cortex is less than 1 mm thick, as occurs in some patients' maxillary sites, and provides inadequate stability on its own.²⁵
- The ideal range of maximum insertion torque appears to be 5–15 Ncm for alveolar sites.^{11,23,29,30,31,32,33} Maximum torque occurs during final seating of the mini-implant and is felt as an increase in resistance on turning a manual screwdriver, such that difficulty in digital rotation typically equates to the top of this torque range. This is clinically valid without it being necessary to measure this in individual patients. In effect, low torque equates to poor *primary* stability (inadequate cortical support) and excessive torque results in *secondary* failure because microscopic bone stress leads to subclinical ischaemic necrosis around the mini-implant threads. This manifests clinically as the mini-implant screwing in with little resistance at the low end of the scale, and it being difficult to manually turn the screwdriver at the high end. Such excessive torque, especially in posterior mandibular

sites, may be avoided by initial perforation of the cortical plate, as described later.

The most important patient determinants of primary stability are the density and thickness of the cortical plates.

- Cortex depth and density are greater in the mandible than the maxilla.³⁴ In theory the mandible may provide greater primary stability, but the reported mandibular success rates are less than those for the maxilla because excessive insertion torque appears to cause high levels of peri-implant bone stress, resulting in secondary microscopic bone necrosis around the threads and hence mini-implant failure.²⁹
- Cancellous bone, which has a similar density in both jaws,^{34,35,36} has little effect on primary stability, except when the cortex is less than 1 mm (as seen in some maxillary sites). In the long-term cancellous bone may influence secondary stability in terms of stabilising the mini-implant body against migration and tipping.^{26,28,37}

Interproximal space

The literature provides data on the *average* amount of interproximal space available for mini-implant insertion, but it is crucial to recognise that there is wide individual variation depending on the adjacent teeth's root size, shape (degree of root taper and curvature) and alignment (root proximity/divergence). In addition, there is more space available on the palatal than the buccal aspect of the posterior maxillary alveolus (e.g. 5 and 3 mm, respectively), due to the differential number and shape of the molar roots, specifically the single palatal versus the two buccal roots of the molars. Therefore, assuming reasonable tooth alignment, the typical buccal alveolar insertion sites for the maxilla are: mesial to the first molar, and adjacent to the canines and central incisors; and for the mandible: adjacent to the molars and premolars.³⁸ Crucially, interproximal space is not an absolute barrier and clinically it may be increased by both oblique insertion and pre-insertion root divergence, as described in Chapter Four.

Soft tissue and oral hygiene

Poor oral hygiene and peri-implant soft tissue inflammation are risk factors for secondary failure.^{1,10,12,39,40,41} Since these problems are more likely

in loose (non-keratinised) mucosa, it is almost always recommended that mini-implants are inserted through attached mucosa. This should minimise soft tissue disruption and the destabilising effects of mobile peri-implant tissue.

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Maxillo-mandibular planes angle (MMPA)

Patients with a high MMPA have an increased risk of failure for maxillary buccal mini-implants because of their relatively thin maxillary buccal cortical plates.^{1,9,40} However, these patients also typically present with an anterior openbite which may benefit from maxillary molar intrusion. Fortunately this problem of poor stability of maxillary buccal mini-implants may be avoided by palatal alveolar mini-implant insertion.^{22,42}

Age

Whilst primary stability is readily achieved in adults, adolescents have a significantly higher mini-implant failure rate.⁴³ This is due to their reduced cortical thickness and density,¹⁶ and higher bone remodelling levels, which may compromise a mini-implant both in terms of primary then secondary stability (less able to withstand loading during the most vulnerable phase of bone resorption within the first month). Therefore, whilst mini-implants are still successful in adolescents it is advisable be cautious and keep the loading force low (e.g. 50g) for the initial six weeks after insertion.

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Cigarette smoking

Heavy tobacco consumption is associated with a significantly higher failure rate.⁴⁴ Therefore, whilst cigarette smoking is not an absolute contra-indication to mini-implant usage, smokers should be warned of the risk and advised to stop before mini-implant insertion.

Mini-implant factors

Mini-implant bodies differ in terms of their dimensions (diameter and length), shape (cylindrical or tapered)

and thread design. Notably, an increase in dimensions leads to greater bone surface engagement. Diameter is the most important factor in terms of primary stability because an increase in diameter leads to increased insertion torque.^{23,24,45,46,47,48} The effect of an increase in body length is much less pronounced than that due to an increase in diameter, with only a subtle increase in insertion torque occurring, because length increases involve the cancellous, not cortical, bone. However, increased body length may be favourable in areas of thin cortical bone by supplementing the cortical support in providing primary stability and especially in reducing the potential long-term drift of mini-implants.⁴⁹ Relatively large diameter mini-implants are also less likely to be deflected by prolonged loading,⁵⁰ and importantly they are more fracture resistant.^{10,51,52,53} However, 2mm diameter mini-implants are not easily accommodated in many interproximal spaces so most mini-implants have mid-body diameters of around 1.5mm.

Diameter is the most important factor in terms of primary stability because an increase in diameter leads to increased insertion torque.

Original mini-implant designs had cylindrical body shapes with self-tapping threads, and required pre-drilling of a full depth pilot hole. More recent designs have used tapered (conical) body shapes and are capable of self-drilling insertion. This is favourable for primary stability since animal and clinical research has shown that tapered designs have a higher insertion torque than cylindrical ones, and also a higher removal torque during the bone healing phases.^{12,23,24,28,53,54,55} This is because self-drilling avoids the risk of thermal tissue necrosis (associated with the heat generated by pilot drilling) and causes less disruption of the peri-implant bone's original histological architecture.^{48,56,57,58,59,60,61,62} However, pre-drilling (perforation) of the cortical plate may still be valuable in avoiding the generation of excessive torque in dense/thick cortex sites, e.g. the posterior mandible, as discussed in the following section on insertion technique.

Finally, the projection of the head into the oral cavity is important since the further away the loading force is applied from the bone surface, the higher the risk of an unfavourable force (moment) at the mini-implant

and bone interface.^{63,64,65} Consequently, it is advisable to use a low profile mini-implant design in order to avoid an excessive head and neck length combination relative to the body length, and to fully insert mini-implants.

Clinical technique factors

Insertion technique

As with all clinical techniques, it is an unfortunate truth that mini-implant success rates increase with clinical experience.^{2,4,12,66,67} Therefore, novices should carefully plan their mini-implant biomechanics and insertion steps, and consider the use of a guidance stent to reduce root proximity risks.^{66,68} Mini-implants may be inserted manually with a customised screwdriver, or by using a contra-angle handpiece. The technique choice is a practical one depending on the ease of intra-oral access and hence screwdriver directional control and handling. However, it is also easier to appreciate and control the insertion torque with a manual screwdriver, whereas tactile sensation is lost with handpiece usage.

The key technique variations which have been studied are whether a pilot hole is drilled prior to mini-implant insertion and whether the insertion should be made perpendicular to the cortex or angled obliquely. Pre-drilling reduces the insertion torque with the greatest effect occurring within the first 2 mm of drilling, i.e. penetration of the cortex.^{28,32,69} This is consistent with the clinical observation of a drop in drilling resistance once the cortical plate has been perforated. Pre-drilling has been associated with an increased mini-implant failure rate in adolescents.⁷⁰ Therefore it is ideal to avoid pilot drilling in young patients and also in maxillary buccal and anterior mandibular insertions, where the cortex is relatively thin and less dense. Conversely, self-drilling mini-implants benefit from perforation of the cortex in areas of dense/thick cortex (specifically the posterior mandible and palate) in order to avoid excessive insertion torque.^{27,40,47,49,50,61} This can be achieved with a cortical punch which only perforates the cortex rather than a pilot drill which readily drills beyond 2 mm depth.⁶⁸

Self-drilling mini-implants benefit from perforation of the cortex in areas of dense/thick cortex in order to avoid excessive insertion torque.

The commercial design of some mini-implants essentially limits their insertion to being perpendicular (90°) to the surface. However, several animal studies have recorded the highest insertion torque values and increased secondary stability with a 20–30° apically directed insertion angle rather than it being perpendicular to the bone surface.^{46,71,72} This is due to enhanced engagement of the cortex and appears to be especially favourable in the maxilla (where the cortex is less robust). Oblique insertions are also favourable in terms of reducing labio-lingual insertion depth and hence proximity to the roots.^{20,73}

Root proximity

Close proximity of the mini-implant body and adjacent roots should be avoided in order to avoid periodontal and root damage, although histological studies show that cellular cementum repair occurs after root trauma.^{56,73,74,75,76,77,78,79,80} In effect, the major problem with close implant–root proximity is that this provides inadequate bone coverage for the threads, destabilises the mini-implant (rather than the tooth), and increases failure rates.^{31,81,82,83,84,85} Indeed, root proximity appears to be more of a risk factor than variations in cortical thickness.⁸⁵ In clinical terms, root contact, or even close proximity, is usually detected during mini-implant insertion by a sharp increase in insertion resistance,^{76,77,86} blunting of the mini-implant tip, patient discomfort (provided that only superficial anaesthesia has been used), and a dull note on percussion of the affected tooth. Consequently, these signs should be taken as indicators of close proximity and the mini-implant withdrawn and re-inserted at a different location or angle.

The major problem with close implant–root proximity is that this provides inadequate bone coverage for the threads, destabilises the mini-implant and increases failure rates.

Force application

Mini-implant loading stimulates a favourable physiological response in the adjacent bone provided that the force level is tolerable. This has been demonstrated in terms of increasing bone–implant contact, and relatively more bone formation (than resorption) and thickening.^{64,87,88,89,90,91,92,93} However, there is no clear evidence currently available regarding

the optimum force levels tolerated by mini-implants. Therefore, it is sensible to be cautious and only apply a light initial force, e.g. 50g during the first four to six weeks, and thereafter limit forces to the normal orthodontic range, e.g. 200g.

It is helpful to understand some relevant concepts of basic bone biology, especially that peri-implant bone is dynamic and undergoes a series of bone healing phases following mini-implant insertion. These phases involve (1) inflammatory acceleration, (2) active bone resorption, (3) a latency or transition period and then (4) predominantly new bone formation. Crucially, mini-implant stability is at its lowest level at the end of the resorptive phase, during the third week in humans, especially in sites with thin cortical layers.^{94,95} This represents the pivotal point between reliance on the diminishing and increasing effects of primary and secondary stability, respectively. Whilst immediate loading is feasible especially in adults,^{8,43,63,87} the results of a prospective clinical study suggest that delayed loading may be beneficial for adolescent patients.⁴³ This may be judged clinically by having a tactile feeling for the maximum insertion torque: if this is felt to be low when manually rotating the screwdriver during the final insertion stage then consider a loading delay of six to twelve weeks.

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Maximising Mini-implant Success: Design Factors

It may be a confusing task for orthodontists to select a mini-implant kit since a large number and variety of systems are now available. These differ from one another in terms of their design features, technique steps, ease of insertion and use (e.g. how traction auxiliaries or wires are attached), versatility, the size and complexity of the kit, clinical recommendations, and the clinical instruction material. It is unlikely that one system provides dramatically better mini-implant stability rates than all of the others and key principles are widely applicable. However, since the treatments and illustrations in this book involve the Infinitas Mini-implant System (DB Orthodontics Ltd, UK, www.infinitas-miniimplant.com [accessed 5th December 2012]; Dentsply GAC, USA, www.gacintl.com) it is worth describing both its generic and distinctive features for clarity and reference purposes. The Infinitas mini-implant is unique in several aspects, especially in its head design and customised three dimensional (3D) guidance stent facility.¹ This chapter describes the key design and clinical features of the Infinitas system's clinical and guidance kits.

Infinitas mini-implant design features

Many mini-implant head designs have two separate tiers represented by (1) a channel or 'X' shaped cross-slots at the top of the head for wire engagement and (2) an external circumferential undercut at a more apical level for the application of traction auxiliaries. In contrast, the Infinitas design has a unique, multi-purpose head which combines cross-slots with both

external and internal undercuts, all on one vertical level (Fig. 3.1). This gives the head a very low profile (intra-oral prominence) whilst enabling the direct attachment of all forms of traction auxiliaries and wires (up to 0.021 × 0.025 inch dimensions). In particular, standard nickel titanium (NiTi) coil springs may be directly engaged, within the internal undercut, on one corner of the bracket-like Infinitas head (Fig. 3.2). Aside from patient comfort, this low profile is biomechanically favourable since it reduces the ratio of the head and neck (extra-bony section) to body length, and hence the risk of adverse tipping moments.²

The Infinitas design has a unique, multi-purpose head which combines cross-slots with both external and internal undercuts, all on one vertical level.

The Infinitas head's precise engineering means that it is a relatively delicate structure. Therefore the insertion screwdriver achieves a secure connection by engaging the neck section, and hence avoids large and potentially deformational forces on the mini-implant head. Consequently the internal shape of the screwdriver closely matches the pentagonal shape of the coronal neck section (Fig. 3.1). The more apical part of the neck is tapered to enable mini-implant insertion at both perpendicular and oblique angles to the cortical plate, maximising cortical engagement yet



Figure 3.1 Diagram of the Infinitas mini-implant head showing its four bracket-like wings, divided by perpendicular cross-slots, and the external and internal undercuts. A rectangular wire is illustrated within the transverse cross-slot.

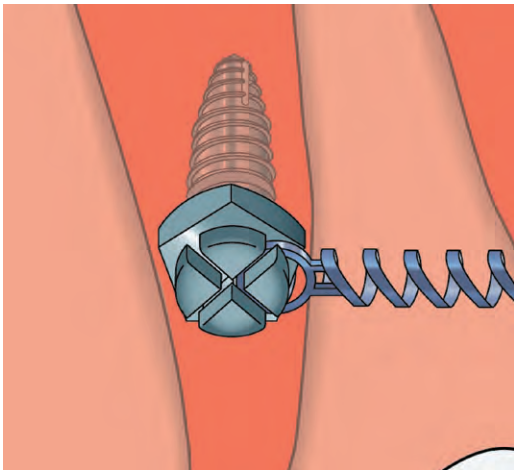


Figure 3.2 Diagram of an obliquely inserted Infinitas mini-implant with a coil spring engaged within the internal undercut of a single wing of its head.

minimising compression of the adjacent mucosa (Fig. 3.3). There are short (1.5 mm) and long (2.5 mm) neck length versions, to allow for the mucosal depth at typical buccal and palatal insertion sites, respectively.³ Whilst buccal insertions are routinely performed with a direct transmucosal technique, a re-usable circular mucotome (soft tissue punch) is used to remove thick (palatal) or loose mucosa prior to insertion of a long neck mini-implant.

The Infinitas body has only four size variables: 1.5 and 2.0 mm diameters (as measured in the mid-body region), and 6 and 9 mm lengths. In combination with the two neck variables and the multi-purpose head design, this means that a range of only five mini-implants provides for all alveolar and palatal insertion options (Table 3.1). This helps to simplify both the

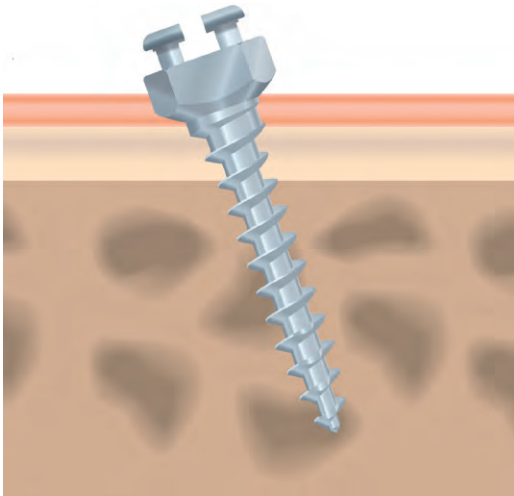


Figure 3.3 Diagram of an obliquely inserted mini-implant where the body traverses the cortical layer at an angle, facilitated by the tapered shape of the neck. Notably, one side of the head is closer to the mucosa than the opposite side.

Table 3.1 The Infinitas mini-implant range and typical insertion sites.

Colour code	Diameter	Body length	Neck length	Typical insertion sites and inclinations
	1.5	9	short	Maxilla: buccal alveolus Maxilla: oblique insertions in anterior alveolus Mandible: oblique insertions
	1.5	6	short	Maxilla: perpendicular insertions in anterior alveolus Mandible: perpendicular insertions
	1.5	9	long	Palatal alveolus (maxilla)
	2.0	6	long	Mid-palate
	2.0	9	long	Edentulous areas

clinical decision-making process and stock keeping. All of the Infinitas bodies feature a self-drilling tip and threads (Fig. 3.4), since self-drilling insertion preserves more original bone than a pre-drilled technique.^{4,5} Engagement of the cortical bone plate, in order to maximise primary stability, is also enhanced by two specific Infinitas design features. First, the thread continues to the coronal end of the body such that it may be fully seated in bone. Second, the 1.5mm (narrow) Infinitas body version has an additional tapered feature at its coronal end, such that the thread diameter gradually widens from 1.5 to 2mm before the junction with the neck (Fig. 3.4). This creates a clinically noticeable increase in torque during the final stage of insertion as the body part engaging the cortex widens from the cylindrical to tapered form, with the effect of increasing primary stability.^{6,7,8} Another benefit of this additional body taper is that it greatly increases strength in this critical coronal area since a 0.2mm increase in diameter can increase strength by 50%.^{8,9} This helps to minimise the risk of fracture of

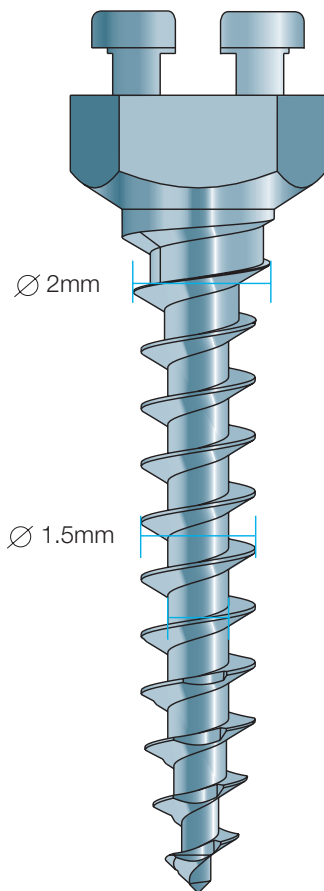


Figure 3.4 Diagram showing how the body's coronal section tapers out from a 1.5 to 2.0mm thread diameter.

the body during insertion and removal.^{10,11} So why not have a 2mm diameter over most of the body length? Unfortunately this would greatly increase the risk of close root proximity in narrow interproximal sites (compared to the 1.5mm mid-body size). Hence, this tapered body design provides a 2mm diameter superficially where it is most beneficial for strength and stability, but avoids root proximity problems since the narrowest inter-root space is frequently 4mm in from the external bone surface.¹²

This tapered body design provides a 2mm diameter superficially where it is most beneficial for strength and stability, but avoids root proximity problems.

Excessive insertion torque is most likely to occur in the mandible and palate where the cortex is relatively thick and dense, leading to pressure necrosis of peri-implant bone and subsequent secondary (delayed) failure.^{5,13,14,15,16} This risk is reduced by pilot drilling, especially within the first 2mm of drilling depth.^{14,17} However, pilot drilling is a nuisance if it requires a low-speed surgical handpiece and saline irrigation (to avoid heat necrosis). Therefore it is ideal to perforate dense cortical bone in order to avoid excess torque, but avoid drilling deep into the cancellous bone, and to simplify the insertion process by avoiding conventional pilot drilling. The Infinitas system achieves this balance with a customised cortical bone punch (Fig. 3.5) which easily perforates dense cortical bone (and the mucosa), with simple slow manual clockwise rotations, up to a maximum depth of 2mm. Its use is recommended for all posterior mandibular and palatal (alveolar and mid-palate) insertions sites in adults, and it is fully compatible with the Infinitas guidance stent. Some orthodontists also prefer to use the punch in buccal sites to initially indent the cortex, without necessarily perforating it. This creates a 'purchase' point and avoids slippage of the mini-implant tip at the start of an oblique insertion.

The Infinitas guidance system

Mini-implant planning involves determination of the optimum mesio-distal and vertical position, and also ideally the vertical and horizontal angles of insertion, i.e. three dimensional (3D) planning is required. However, it may still be difficult to accurately position a mini-implant, typically in posterior or palatal locations,

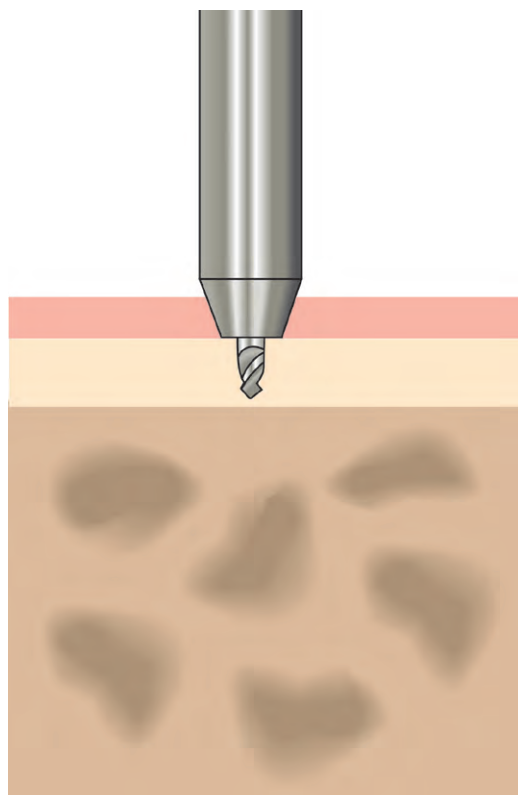


Figure 3.5 Diagram of the Infinitas cortical bone punch traversing the mucosa and inserting into a thick cortical layer.

because of restricted visual and instrument access. Further discrepancies may arise when the planning and insertion processes are carried out by an inexperienced orthodontist, or especially by different clinicians (e.g. an orthodontist and surgeon). In the latter situation it is ideal if the orthodontist avoids the need to fully describe the insertion site, angles and clinical plan to the other clinician, and then hope that this plan is both understood and followed. Instead the 3D positional information should be clearly dictated by a stent, removing the need for educated guesswork or improvisation by the surgeon. Unfortunately, placement of an interproximal wire or a custom-made wire guide at the approximate insertion site or on an adjacent fixed appliance usually only indicates the insertion site and not angles of insertion. This approach is also prone to radiographic parallax errors. Even techniques using a circular guide tube allow excessive lateral play of the insertion instrument,¹⁸ and partly rely on visual alignment of the mini-implant with the tube's adjacent edges unless the screwdriver is physically steered by engagement within the guide tube.



Figure 3.6 Handpiece insertion of an Infinitas mini-implant on the palatal aspect of the alveolus, where the end of the screwdriver insert fits within the 3D stent. The mini-implant's body can be seen through the plastic guidance cylinder.

These problems can be minimised by the use of a stent capable of reliably transferring the 3D prescription from the planning to the insertion stages, and then physically guiding the insertion process. It is also ideal if relatively little laboratory expertise and cost are required. The Infinitas guidance system meets these requirements by using three simple components: a mini-implant analogue, abutment and guide cylinder which work with a plastic baseplate to form an insertion stent for precise control of insertion instruments (Fig. 3.6). There are six simple steps involved in the fabrication of this stent, and these may be carried out by an orthodontist (with access to a vacuum or pressure forming machine) with or without the assistance of an orthodontic technician (following the orthodontist's prescription) as described here.

A stent capable of reliably transferring the 3D prescription from the planning to the insertion stages.

1. Plan the insertion details using a dental model and radiographs

The optimum position and angulations for each mini-implant are determined by mentally combining radiographic information (e.g. a periapical view of



Figure 3.7 Drilling of the palatal aspect of a plaster model, with the drill angled towards the contact point of the molars and at the planned inclination (approximately 90° to the sloping surface).

the interproximal space) with the topographical features of a plaster model of the dental arch. In effect, it is much easier to visualise the insertion angles on a model than in the patient's mouth, and the surface contour of the model typically highlights the appropriate insertion space as a concave indentation between tooth roots. In order to preserve as much detail as possible, it is important to avoid waxing/blocking out any fixed appliance brackets near the insertion site when a dental impression is recorded for stent fabrication.

2. Drill a pilot hole in the model

A pilot hole is drilled in the dental model at the planned vertical and mesio-distal insertion point and angles, using a plaster drill and a dental handpiece (Fig. 3.7).

3. Insert the mini-implant analogue into the model

The analogue is manually screwed into position in a clockwise direction, using the guidance kit screwdriver. If in doubt, the analogue should only be partially seated until its 3D position has been checked, so that an alteration of the insertion site/directions is easily made by further drilling.

4. Fit the abutment onto the analogue

The abutment is manually fitted onto the head of the analogue and usefully amplifies the analogue's insertion angles (Fig. 3.8). If the 3D position of the analogue appears to be suboptimal then it should be removed from the model and the insertion



Figure 3.8 (a) Infinitas analogues have been inserted into pre-drilled holes on both sides of the model and an abutment has been fitted onto the right sided one. The buccal abutments are being used in photograph (b) to confirm whether the insertion angles pass along the line of the second premolar–first molar contact points.

process repeated with different location/angulation details (after filling in the plaster hole as necessary). In particular, it is much easier to refine the position in a dental model at this stage than in the patient's mouth at the insertion visit!

5. Slide the guide cylinder over the abutment

The internal diameter of the cylinder is similar to the external diameter of the abutment, ensuring a close fit between their surfaces.

6. Form the stent baseplate

The assembled combination of dental model, analogue, abutment and guide cylinder components



Figure 3.9 A finished insertion stent where the insertion hole in the plaster model is seen in the centre of the guidance cylinder, and the baseplate covers the four posterior teeth and adjacent palatal alveolus.

are placed into a pressure or vacuum forming machine such as one used for orthodontic retainer fabrication. The stent baseplate is then formed using a thick (1.25 or 1.5 mm) thermoplastic blank. This is much thicker than retainer blanks, in order to reduce flexing of the stent (if the screwdriver is leant upon). The baseplate, incorporating the guide cylinder, is then trimmed to the desired size, usually incorporating four or more crowns and the insertion site (Fig. 3.9). If there are already brackets on the teeth then the baseplate edge should be trimmed clear of them.

It is also now possible to produce a 3D stent directly from a 3D CT or cone beam CT scan, using orthodontic planning software such as Vistadent (Dentsply-GAC, USA, www.gactechnocenter.com [accessed October 2012]) (Fig. 3.10). In the future it is likely that this process will supersede the manual production of stents. All three Infinitas insertion instruments (soft tissue and bone punches, and the screwdriver) fit precisely into the guide cylinder (Fig. 3.6) with the same degree of precision as occurs between the guide cylinder and its abutment. The physical guidance provided by the Infinitas stent has several additional benefits. First, it provides a stable insertion point and avoids slippage of the mini-implant tip during oblique insertion. Second, it reduces directional variation which minimises both flaring of the insertion bed and the risk of fracture of the mini-implant. Finally, it minimises radiographic needs since no additional radiographs, taken with a guide or provisional stent in situ, are required.

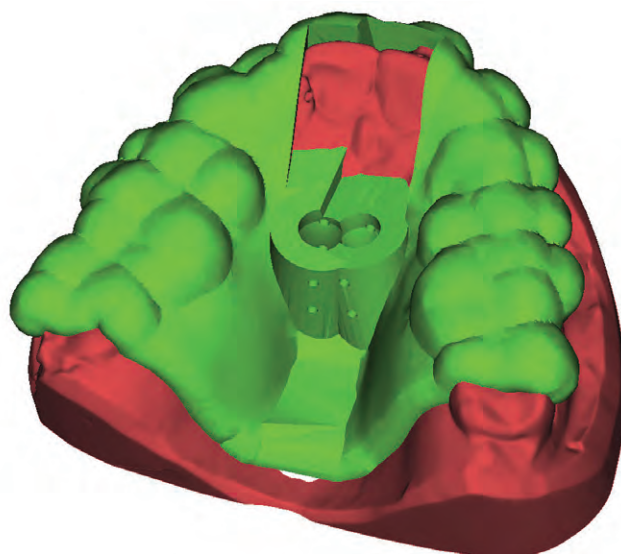


Figure 3.10 Diagram of a (green) computer generated guidance stent, with twin mid-palatal cylinders, superimposed on a (red) digital model of the maxillary arch.

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Introducing Mini-implants to Your Clinical Practice

Patient consent

It is important that you feel comfortable with both your proposed treatment plan and the favourable risk–benefit ratio for mini-implants during the consent process. It is also very helpful to use patient-friendly terms, and to help educate patients by using a fixed appliance typodont model with one or several mini-implants in situ, and possibly clinical photographs of the proposed treatment scenario. When you are starting to use mini-implants in your clinical practice, it may be worth pre-preparing an explanatory sentence or two which can ‘roll off your tongue’, such as: ‘we wish to move your teeth in this direction and need an anchor point to help achieve this. This little anchor, known as a mini-implant, may sound a bit daunting, but it is easily fitted by numbing just a small patch of your gum. It is even easier to remove later in your treatment, but this means that about one in ten anchors doesn’t achieve full stability and comes loose itself. This isn’t painful or harmful, but it is a nuisance since the mini-implant then needs to be replaced after a few months.’

It is also very helpful to use patient-friendly terms, and to help educate patients by using a fixed appliance typodont model.

It is important to document that the treatment details, mini-implant usage and potential problems

have been fully discussed, including whether a mini-implant information sheet has been given to the patient (which is very useful as a routine step). This does not necessarily require a separate mini-implant consent process and form, in the same way that several types of orthodontic appliances may be included within a single treatment plan description. Instead, this topic is included as an integral part of the overall treatment options, plan and consent process. In the same vein, where relevant it may be appropriate to charge private patients in terms of their whole treatment plan, rather than having a separate add-on fee for mini-implant anchorage. The exception to this may be if you are planning for a colleague to insert the mini-implant(s) on your behalf, in which case fees and liabilities will need to be pre-agreed by the involved clinicians.

The main points to cover in written and verbal formats are listed below. It may not be appropriate to highlight all of these details to every patient, especially once you have experience and are able to discern those risks which are realistic or recurrent possibilities in your own clinical practice. A clinical audit of your caseload will provide valuable information and indicators of possible areas to focus on in this respect.^{1,2} This will also assist with clinical governance assurance. Such an audit is easy to conduct if you keep an up-to-date database of your mini-implant cases. A sample database spreadsheet, used for case compilation and audit, is shown in Table 4.1.

Table 4.1 A clinical database for mini-implant audit purposes.

Patient ID	Patient name	DOB	Malocclusion / mini-implant use	Insertion site(s)	Number inserted	Insertion date	Removal date	Design / size	Comments
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

Key points to consider for valid consent**1. The rationale for mini-implant anchorage.**

What are the benefits for this patient's treatment and what are the alternatives.

2. Patient discomfort.

Reassure the patient that this typically feels like a dull pressure ache and it is self-limiting (usually resolving within one day of insertion).

3. Mini-implant instability.

Explain that there is an 80–90% success rate, and that mini-implant failure does not cause any permanent harm or infection problems. In the case of a failing mini-implant, premature mobility will be detected by the orthodontist and rarely causes patient discomfort.

4. Periodontal/root contact.

If close root proximity occurs during insertion then it is usually indicated by an uncomfortable sensation felt in the nearest tooth, and the orthodontist can then alter the mini-implant's position. Even in the event of tooth contact, the root tissues heal uneventfully and there is no risk of clinically detectable or long-term tooth damage. The major problem with close root proximity or contact is that it is likely to lead to mini-implant failure.

5. Mini-implant fracture.

This occurs in only a small percentage of cases, especially when correct planning and technique steps are followed (e.g. pre-drilling or perforating sites with dense cortical bone prior to insertion).

Surgical removal of a fractured piece may only be required if it is likely to interfere with subsequent tooth movements or in the unlikely event that inflammation occurs (when the mini-implant is not sealed over by the adjacent soft tissues). On such rare occasions it may be appropriate for the removal of a fractured part to be undertaken by an oral surgeon. This involves gaining access via a small mucoperiosteal flap and trephination of a narrow collar of bone around the mini-implant end, to enable the fractured fragment to be gripped and derotated out of the bone.

6. Mini-implant displacement.

This is not usually an issue from the patient's perspective since it may only be noticed by them if it interferes with oral hygiene and gingival hyperplasia occurs. Migratory movements do not cause pain per se. However, mini-implant displacement is more likely to occur in areas with thin cortical bone and occasionally warrants mini-implant replacement.

7. Written information.

This is best supplied in the form of a patient information sheet such as those produced by individual mini-implant distributors and professional bodies, e.g. the American or British Orthodontic Societies (www.bos.org.uk/index/patientinformationleaflets/orthodonticminiscrews [accessed October 2012]). An example of a distributor's patient leaflet is given in Fig. 4.1.



Patient Guide To Temporary Anchorage Devices (TADs)



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Figure 4.1 The two sides of a mini-implant patient information leaflet, which highlights the salient points of mini-implant usage and patient instructions, as part of the consent process. With kind permission from Dentsply GAC International.

Infinitas Temporary Anchorage Device (TAD) System

Congratulations! You and your orthodontist are benefiting from a revolutionary new and research-based orthodontic treatment. Your orthodontist has received specialist training in this technique in order to make your brace treatment as efficient and effective as possible.

What Is A TAD?

It's a very small (diameter 1.5 - 2mm) specially engineered titanium alloy screw which is placed into your gum and jaw bone thereby acting as an anchor point and greatly assisting with the precise movement of your teeth.

Will It Be Painful?

Local anaesthesia is used to numb a small area of your gum, and the mini implant is then gently inserted. You may experience an odd pressure sensation as this occurs. Once the numbness wears off you may feel some discomfort within the first 24 hours and approximately 50% of patients report taking simple painkillers (e.g. ibuprofen or acetaminophen) to resolve this.

Will It Hurt When It Is Removed?

TADs are simply removed when no longer needed, usually without the need for any anaesthesia - it's that easy!

The TAD site heals painlessly within several days after removal.

How Long Will The TAD Be In Place?

Your orthodontist will determine how long the mini implant will be required, but in most cases you can expect to have it in place for a few months, however, it can be left in longer as necessary for individual patient requirements.

Should I Expect Any Problems?

Research indicates that TADs do not damage your teeth or other mouth tissues. The vast majority of mini implants remain stable during brace treatment and cause little nuisance. However, on occasion they can become loose prematurely. This is rarely painful, but may warrant mini implant replacement. If you have any questions or concerns about TADs speak to your orthodontist.

What Do I Need To Do?

Rinse this area with a anti-bacterial mouthwash, e.g. chlorhexidine, twice a day for the first five days.

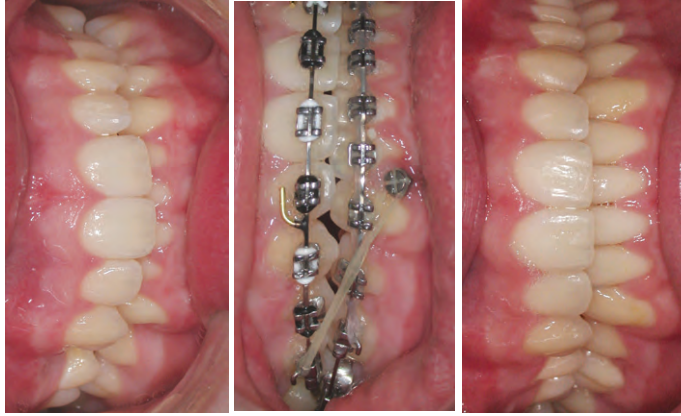
During treatment, dip a small toothbrush in chlorhexidine mouthwash and use it to gently clean around the top of the mini implant.

Avoid using an electric toothbrush on the mini implant itself.

Don't fiddle with it!

What If The Implant Causes Irritation?

Place a small amount of orthodontic wax over the head of the TAD. If the irritation persists contact your orthodontist.



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Figure 4.1 Continued

Staff training

This is straightforward, especially for any mini-implant system with a relatively small number of instruments and inventory (which makes it easy for staff to keep control of the stock). It is essential that your staff is familiar with the mini-implant kit and also understand the requirements for its sterilisation, cross-infection control and the aseptic nature of the insertion procedure. This may be easier if pre-sterilised mini-implants are used (inserted directly from their sterile packaging). Notably, sterile gloves are not essential provided that only the untouched ends of sterile instruments are used to directly handle the mini-implant.

Orthodontic nurses and therapists readily understand the concept of anchorage reinforcement and may be able to relate this to their experiences of trying to encourage headgear wear. Once they have seen mini-implants being used, and the results achieved, they are often enthusiastic advocates for this treatment adjunct.

Patient selection

Broadly speaking, when it comes to case selection there are two categories in terms of anchorage requirements and treatment options: routine and complex cases. On one hand, it is easy to become

familiar with mini-implant insertion and usage in a routine case, such as a patient who needs posterior anchorage reinforcement during retraction of the labial segment. In this scenario, the mini-implants are inserted in buccal positions using a manual technique such that hands-on experience is gained, and the overall treatment plan and progress are readily understood, tangible and relatively predictable. Hence, the effects of mini-implant anchorage may be gauged in a controlled clinical scenario.

Alternatively, at the start of your mini-implant usage you may feel more comfortable justifying their use in a complex case, such as an adult with multiple absent (anchor) teeth where the treatment options are very limited. Again, it is advisable to select a patient where manual (buccal) insertions are indicated, rather than 'jumping in' with a case requiring handpiece insertion and biomechanics which markedly differ from conventional (anchorage) approaches, e.g. molar intrusion with palatal mini-implants and a modified transpalatal bar.

References

1. Mistry PM, Cousley RRJ. An audit of mini-implant success rates. *Brit Orthod Soc Clin Effect Bull* 2009; 22: 13–15.
2. Cousley RRJ. A re-audit of orthodontic mini-implant success rates. *Brit Orthod Soc Clin Effect Bull* 2011; 26: 7–9.

Planning and Insertion Techniques

As with all orthodontic treatments it is important to properly plan each mini-implant case and the following general principles should help inform this diagnostic and treatment planning process. This chapter provides as comprehensive an aide memoire as possible, which at first glance suggests that there is a lot of information to analyse and remember. However, not all points apply to every case and experience will quickly lead you to discern the relevant steps for individual cases. In addition, common clinical scenarios are described in a sequential manner in the remaining book chapters and, whilst this entails some degree of repetition, it ensures that nothing relevant is left out for each clinical scenario.

Mini-implant planning

Treatment goals and anchorage requirements

Determine these as per your normal orthodontic assessment and treatment planning regimen. The only differences may be that your treatment options and expectations may be greater than with conventional treatment, e.g. achieving full overjet reduction in a Class II case, or non-surgical correction of an anterior openbite.

Mini-implant location

Consider the ideal antero-posterior and buccal/palatal site(s) from both anchorage and biomechanical perspectives. For example, since incisor retraction requires posterior anchorage, the typical insertion site for this purpose is the buccal side of the alveolus

between the second premolar and first molar teeth. This is because more anterior insertion sites may not provide sufficient range for traction and may steepen the vector of traction, which may introduce vertical side-effects. Buccal mini-implants are also easier (than palatal ones) to attach directly to a labial fixed appliance. The optimum insertion sites will be described in detail in each specific clinical scenario chapter.

Consider the ideal antero-posterior and buccal/palatal site(s) from both anchorage and biomechanical perspectives.

Hard tissue anatomy

Assess each insertion site in terms of the interproximal space in three dimensions (3D), i.e. its mesio-distal width and alveolar depth; the positions and shape of adjacent tooth roots; the proximity of nearby structures (e.g. the maxillary sinus); and the bone quantity (in particular, whether there is alveolar necking or conversely a convex alveolar morphology). Much of this information can be derived from radiographs (Figs 5.1a,b). Periapical radiographs are preferable to panoramic views since the latter may misrepresent the shape, position and angulation of roots, and make it difficult to identify mesial bowing of the mesio-buccal molar root. However, periapicals are prone to parallax errors if a film or sensor holder is not used for

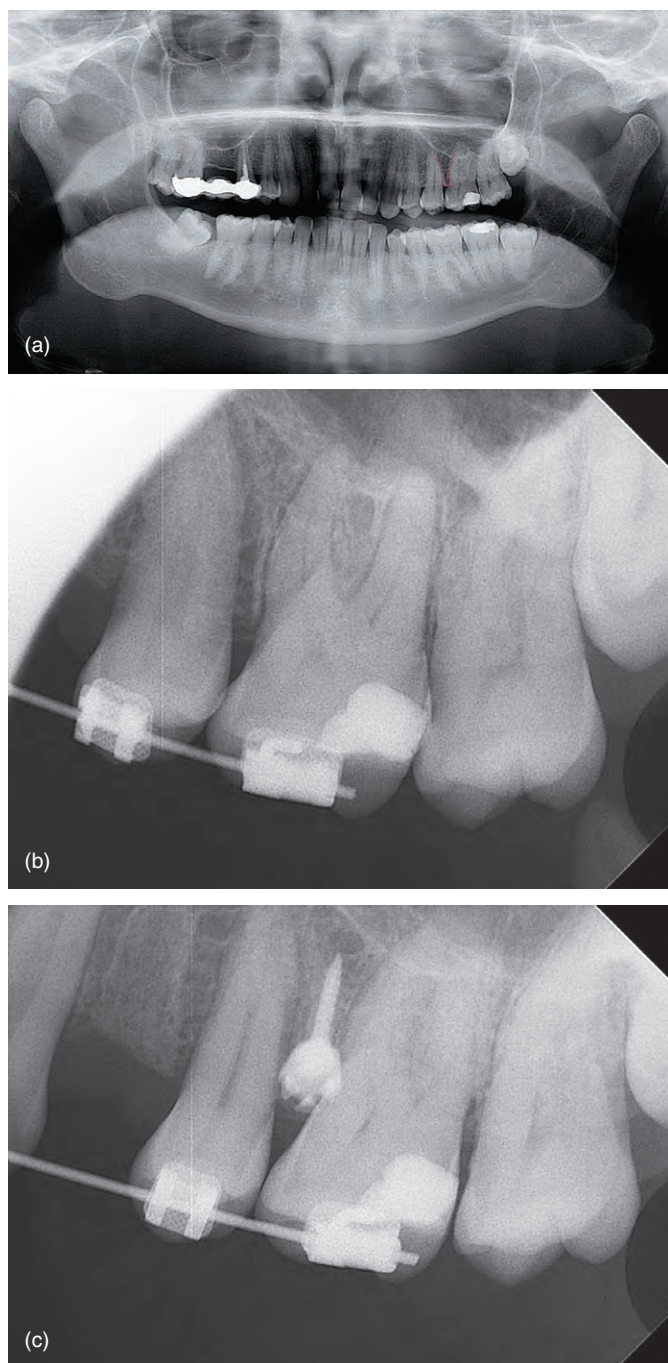


Figure 5.1 (a) Panoramic and (b) intra-oral pre-treatment radiographs of the dentition as used to visualise the interproximal area between the left maxillary second premolar and first molar teeth. (c) The intra-oral radiograph is repeated to confirm the position of a mini-implant in this site.

standardisation (Fig. 5.1c). Cone beam computerised tomography (CBCT) provides the clearest amount of detail in 3D (Fig. 5.2), including estimations of the cortical thickness and density, but this is not yet widely available nor considered essential for mini-

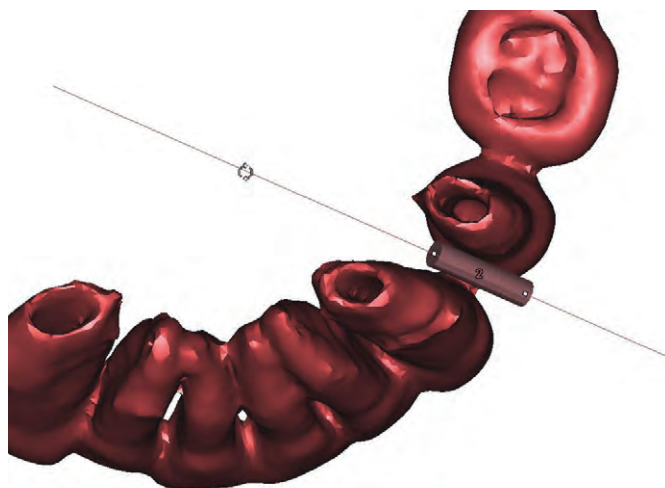


Figure 5.2 A rotated CBCT image with a cylinder representing the position and orientation of a virtual mini-implant distal to the canine root. This also shows the proximity of the cylinder to the adjacent roots.

implant planning. The exact insertion site and insertion angles are determined by studying each patient's radiographs, supplemented by examination of the patient (especially to highlight soft tissue details) and either their dental or virtual model (to give a 3D appreciation). Interestingly, it is often easier to observe surface undulations on a physical model than in the patient's mouth, where a surface concavity indicates the interproximal area between the prominences of adjacent roots.

Soft tissue anatomy

Mini-implants should be inserted through the attached gingiva (not loose mucosa) in order to minimise the risk of either the cheek or lip soft tissues wrapping around the mini-implant threads during insertion; and later destabilisation of the mini-implant from subsequent plaque accumulation and (mobile) soft tissue movements. The occlusal boundary of the attached tissue is superficially indicated by the gingival margin. However, remember that the correct limit, set by the alveolar bone crest level, is approximately 2 mm more occlusal than the soft tissue margin. The apical boundary (on the buccal aspect) is formed by the mucogingival junction (MGJ) and any adjacent frenal attachments (Fig. 5.3). Insertion close to the MGJ usually provides access to the largest interproximal alveolar space, but beware that the apparent height of buccal attached gingiva is artificially exaggerated on a

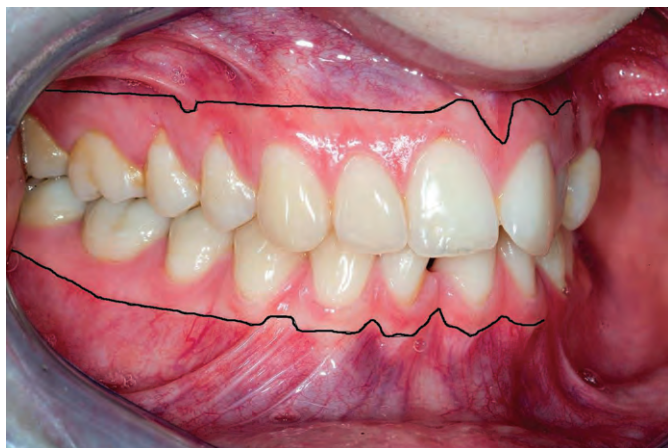


Figure 5.3 The upper and lower mucogingival junctions are highlighted as black lines between the attached and free mucosal tissues.

dental model because the sulcus is easily stretched during the impression process. Therefore, if you are using a dental model to plan a buccal alveolar insertion, first record the clinical height of the attached gingiva (distance from the gingival margin) at the impression appointment, or verify it from clinical photographs. The apical insertion limit on the palatal side of the maxillary alveolus is best determined by palpation of the tissues to determine areas of firm attachment. Palatal alveolar insertions should be planned in areas where the mucosa displays little sign of mobility and compressibility.

The apparent height of buccal attached gingiva is artificially exaggerated on a dental model because the sulcus is easily stretched during the impression process.

Vertical location and inclination

The vertical level and angle of a mini-implant insertion are affected by two factors: the interproximal bone space and the height of attached gingiva. An ideal mini-implant insertion site should provide at least a 0.5mm margin of bone around the threads, with it generally being the case that greater interproximal space is available at more apical levels, due to the tapering shape of the adjacent roots. The exception to this rule may occur when a maxillary molar is absent and the sinus floor has migrated in an inferior/occlusal

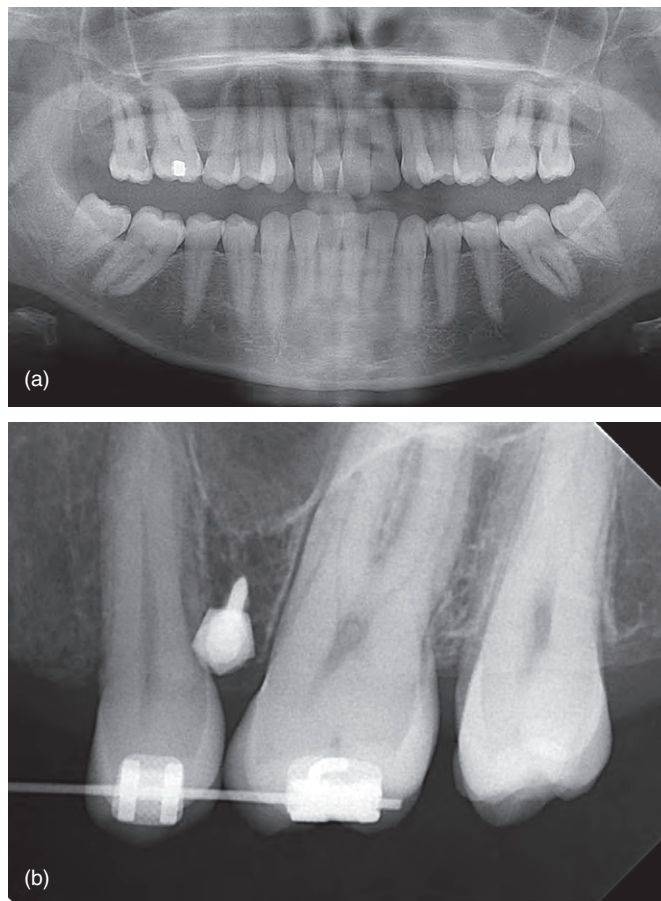


Figure 5.4 (a) Pre-treatment panoramic and (b) intra-oral post-insertion radiographs of an adult with early loss of all first molars. The maxillary sinus floor is at a relatively coronal level bilaterally, which limits the vertical (apical) level of mini-implant insertion.

direction, limiting mini-implant insertion to a relatively coronal level at this site (Fig. 5.4).

The overlying soft tissue is relevant since this dictates the range of vertical levels available for insertion through the attached gingiva. However, this choice may be limited in patients with only a narrow band (height) of attached gingiva, such that the mini-implant needs to be inserted at an oblique angle (e.g. 20–30° in the maxilla, 10–20° in the mandible) in order to keep its neck (and head) at a relatively coronal level, within the attached gingiva, whilst directing its body apically between the roots (Fig. 5.5).¹

In turn, a mini-implant's vertical level and angle of insertion influence its head position, emergence profile and ease of attachment. In particular, the head of an obliquely angled mini-implant, when inserted in an area of restricted attached gingival height, emerges at a relatively coronal level and its lateral (buccal) edge will

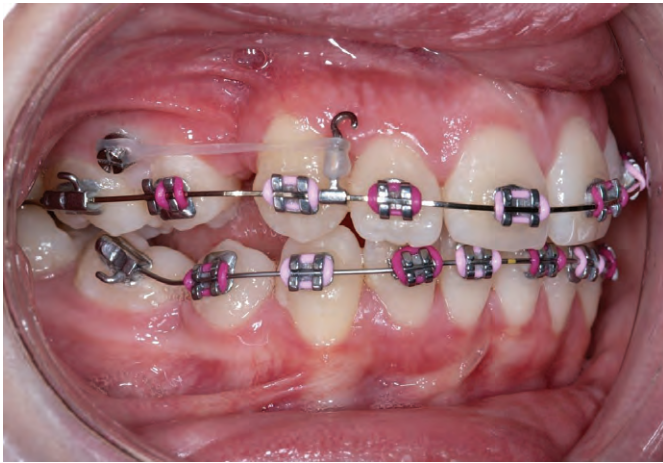


Figure 5.5 The clear elastomeric attachment provides horizontally orientated traction from the mini-implant head directly to a powerarm on the fixed appliance, for en masse retraction of the anterior teeth.

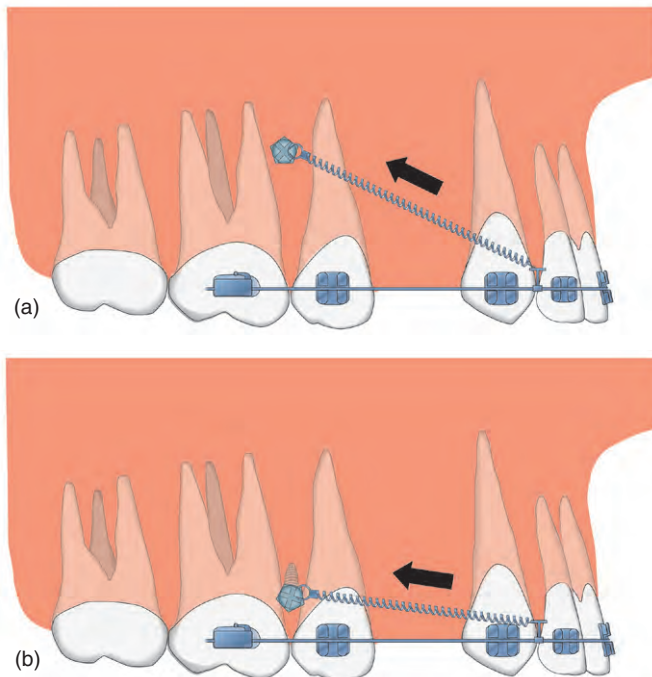


Figure 5.6 Diagrams of (a) oblique and (b) horizontal vectors of traction to the anterior teeth from a buccal mini-implant inserted at a relatively apical and coronal level, respectively.

be more prominent than the medial (palatal) aspect. Furthermore, the vertical position of the head affects the vector of force application such that an apical head position potentially produces an oblique traction vector (Fig. 5.6a) compared to a position closer to the fixed appliance level (Fig. 5.6b). This aspect will be discussed further in the chapters on clinical biomechanics.

Insertion timing

Determine this relative to the fixed appliance bond-up, by deciding how much arch alignment is appropriate before mini-implant insertion. Crucially, if there is insufficient interproximal space at the planned insertion site then consider a preliminary phase of fixed appliance treatment in order to diverge the roots and hence facilitate mini-implant insertion (Fig. 5.7). This is achieved by bonding the bracket(s) with a modified tip, especially adding mesial tip to the normal second premolar bracket orientation (Fig. 5.8). Indeed, I routinely perform this step prior to the majority of buccal insertions since it is a simple process which can make mini-implant treatment much easier. The bracket position is then corrected during the fixed appliance finishing stage (after explantation). Furthermore, it may be biomechanically beneficial to align the full arch such that it is ready to accommodate a rigid (e.g. 0.019 × 0.025 stainless steel) archwire and powerarm by the time of mini-implant insertion. This helps with sliding mechanics and the reduction of unfavourable vertical side-effects.

Consider a preliminary phase of fixed appliance treatment in order to diverge the roots and hence facilitate mini-implant insertion.

Guidance stent

Fabricate a stent (as described in Chapter Three) if you think that it will be helpful for the insertion stage. This depends on factors such as your level of experience and the ease of visual and physical access to the insertion site. In particular, even experienced orthodontists find a stent very useful in posterior areas which are difficult to see by direct vision and reach with a manual screwdriver and/or where the interproximal space is limited (requiring a high degree of insertion accuracy). Clinicians who are new to mini-implants may also find a stent useful for the majority of locations. If a stent is to be fabricated by a laboratory then it is best that you fully plan the insertion site and angles on a working model and then pass this to the technician, so that the orthodontist is directly responsible for planning the case. In addition, it is advisable to give one to two weeks between impression and insertion appointments for this process to be undertaken.

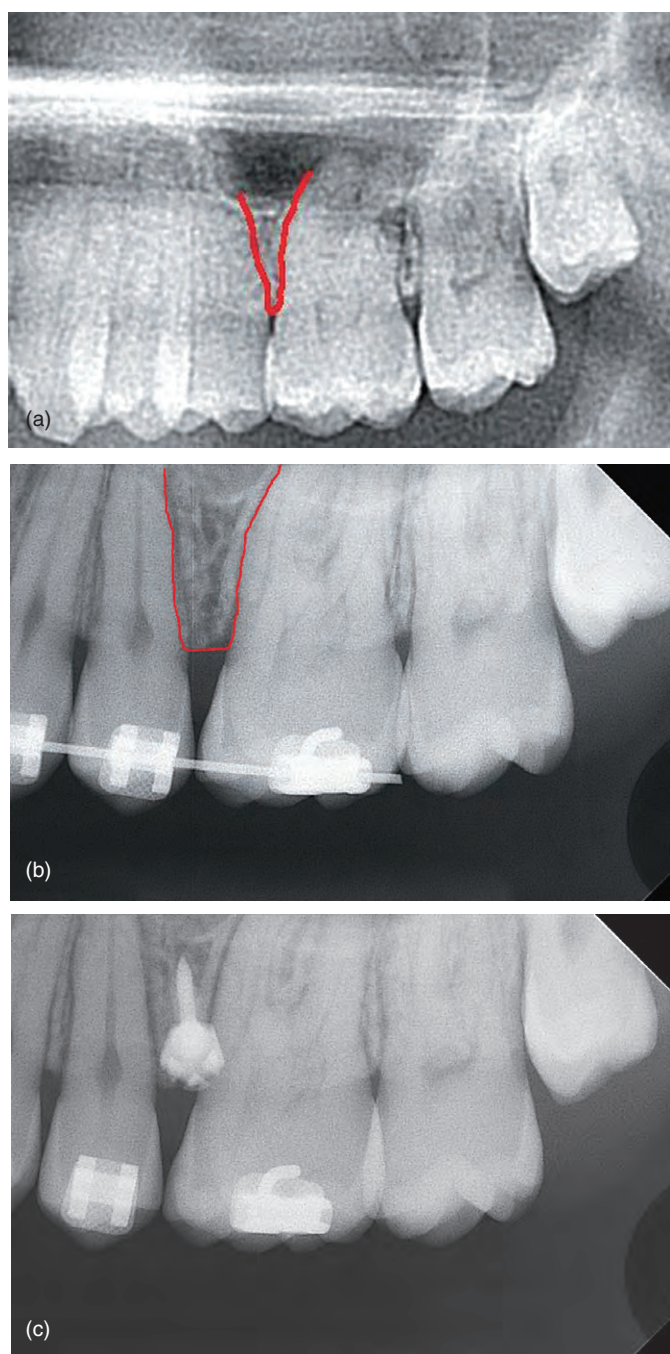


Figure 5.7 (a) A pre-treatment panoramic, and (b) pre-insertion and (c) post-insertion intra-oral radiographs. The insertion site between the left maxillary second premolar and first molar roots is highlighted in red in images (a) and (b). Root divergence has been performed to widen the interproximal space before radiograph (b) was taken.

Mini-implant dimensions

Determine the optimum *body* diameter and length primarily according to the insertion site, but also considering general patient factors such as age, and to a lesser extent body mass (Table 5.1, Fig. 5.9). In

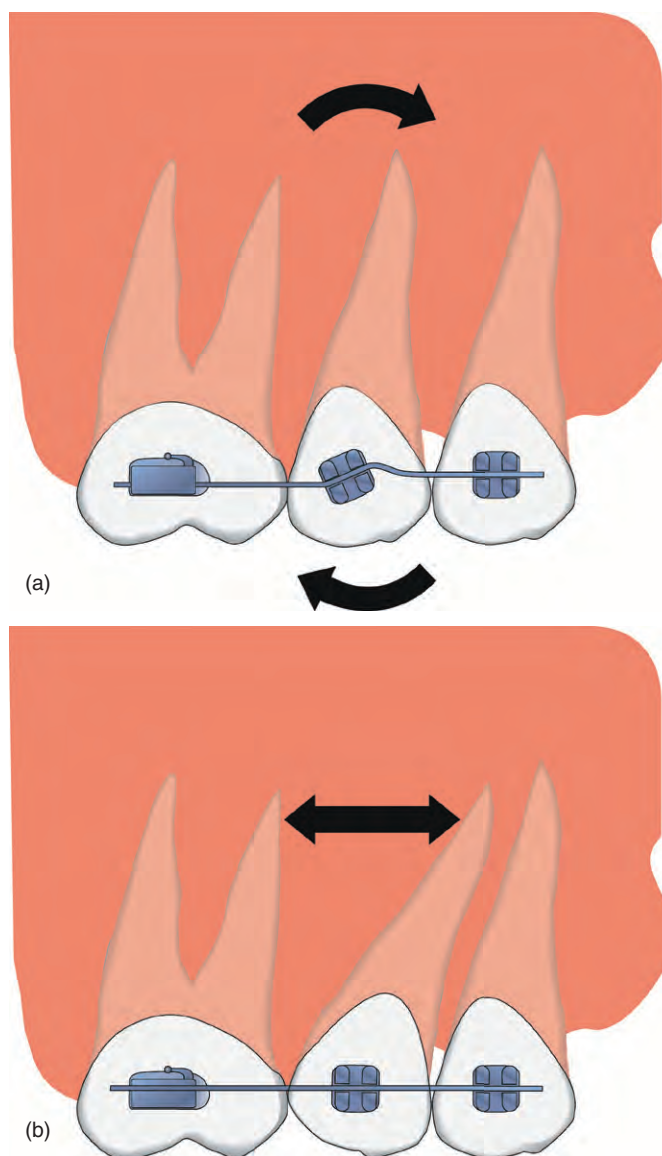


Figure 5.8 Diagrams of the premolar and first molar teeth where (a) the second premolar bracket has been bonded with mesial tip to cause (b) mesial tipping of this root during the fixed appliance alignment phase and hence an increase in this interproximal space.

general, narrow diameter mini-implants (e.g. the Infinitas 1.5mm version) are selected for interproximal sites, whereas a larger diameter (e.g. 2.0mm) may be safely inserted in edentulous sites and the mid-palate. A long (e.g. 9mm) body length is ideal for posterior maxillary sites since this length gains additional stability (from cancellous bone engagement) in such areas with potentially suboptimal cortical bone support (depth and density). However, short (e.g. 6mm) length mini-implants are likely to have sufficient stability in adult patients in areas of thick and dense cortical

Table 5.1 Clinical scenarios where additional details dictate that a wide diameter or long length mini-implant may be advantageous (compared to standard adult conditions).

Secondary Clinical Consideration	Diameter Variation	Length Variation
Adolescent patient with reduced cortical support (compared to an adult).	2.0 rather than 1.5 mm: increases bone engagement, more feasible in palatal alveolar (wide interproximal space) and mid-palate sites.	9 rather than 6 mm: increases secondary stability, e.g. in a posterior mandibular site.
Elderly patient, especially post-menopausal female.	2.0 rather than 1.5 mm: increases bone engagement.	9 rather than 6 mm: increases secondary stability.
Patient with a low body mass index where cortical thickness may be reduced.	2.0 rather than 1.5 mm: increases bone engagement, e.g. in palatal sites.	9 rather than 6 mm: increases secondary stability.
Thicker than average or spongy palatal soft tissues.	2.0 rather than 1.5 mm: allows for incomplete body insertion.	9 rather than 6 mm reduces tipping moment effect (due to higher profile head projection).

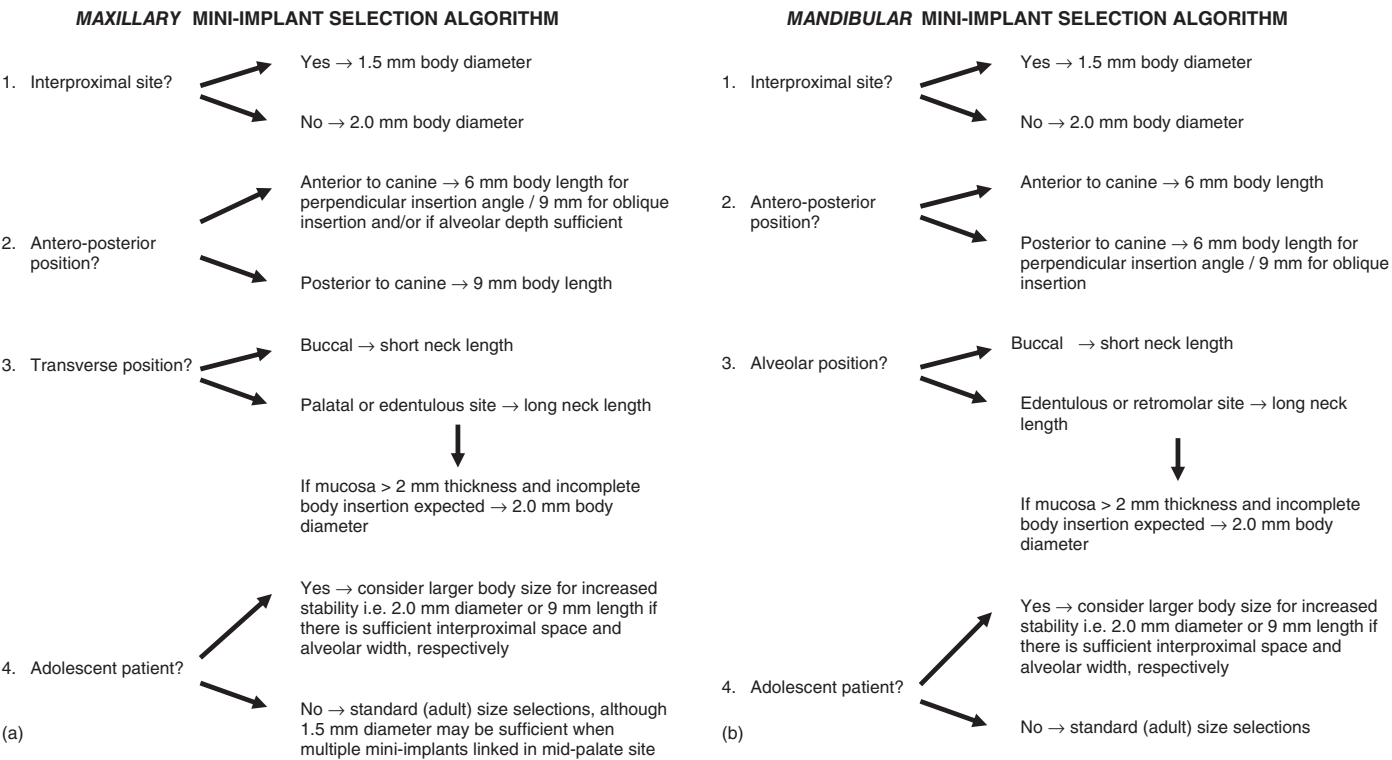


Figure 5.9 Algorithms (flowcharts) highlighting the most common considerations in the selection of optimum mini-implant body and neck dimensions according to the planned insertion site and directions.

plates, e.g. the posterior mandible and mid-palate. In addition, a short body length is preferred for horizontal (perpendicular) insertions in sites with limited alveolar (bucco-lingual) or palatal bone depth, e.g. the anterior maxillary and mandibular alveolus, and the mid-palate. The bone depth in such sites may be gauged on a lateral cephalograph (Fig. 5.10) or a CBCT. If the depth

is too shallow then the mini-implant tip may perforate the palatal/lingual side of the alveolus or nasal floor, respectively. This is less likely when mini-implants are inserted obliquely hence enabling the safe use of 9mm body length versions in the anterior alveolus, especially if the insertion level is restricted by a narrow band of attached gingiva (Fig. 5.5).

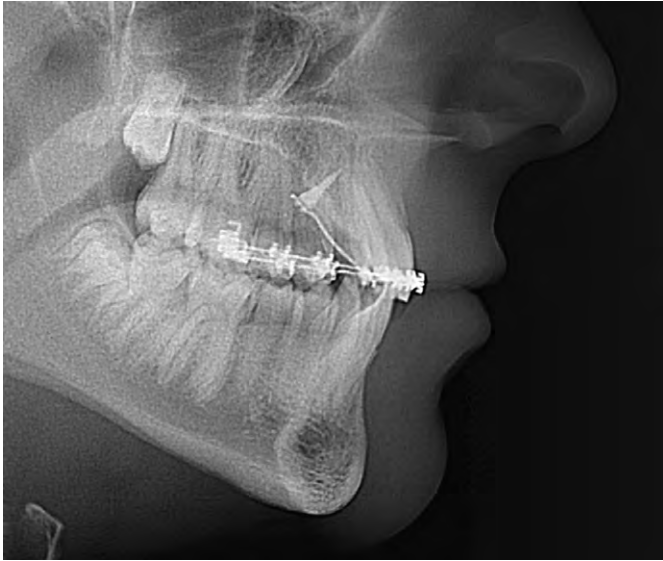


Figure 5.10 Lateral cephalogram showing the palatal bone thickness, the width of the maxillary and mandibular alveolar processes, and a 6mm length mid-palate mini-implant angled towards the anterior nasal spine. An indirect anchorage wire was shaped to follow the anterior palate's contour.

Determine the optimum *body* diameter and length primarily according to the insertion site, but also considering general patient factors such as age and, to a lesser extent, body mass.

Variations also occur in the length of mini-implant necks. In general, a short (e.g. 1.5mm) neck is appropriate for most buccal insertions, where the mucosa is thin; and a long (e.g. 2.5mm) neck version is used in areas with thick or loose mucosa, e.g. palatal and edentulous sites. This is a very useful rule of thumb, but if necessary the tissue thickness may be double checked, once the tissue has been anaesthetised, by directly measuring the depth of the mucosa using a dental probe with an endodontic stopper on the end.

Mini-implant insertion

Mini-implant kit sterilisation

The manufacturer's recommended sterilisation regimen must be followed so that the mini-implant kit and mini-implants (if purchased non-sterile) are available in a sterile state ready for the scheduled appointment. Technically, sterile patient drapes and gloves are not required provided that the mini-implants

and the free ends of the instruments (which contact the tissues) are untouched by the non-sterile gloves and instead only handled using sterile instruments such as the mini-implant screwdriver or an orthodontic instrument such as a Weingart plier.

Superficial anaesthesia

Either local (LA) or topical anaesthetic agents may be used to achieve superficial anaesthesia. Unfortunately profound topical anaesthetics are not readily obtainable in many countries such as the UK and commercially available agents may provide insufficient anaesthesia. Furthermore, LA is more effective in thick mucosa, plus the appearance of soft tissue blanching indicates that the insertion may proceed immediately. In contrast, topical agents require at least three minutes of tissue contact, even for thin buccal tissue sites.² However, topical application is still beneficial at the start of the procedure to reduce the discomfort of the injection, especially if one is injecting directly into the mucosa at the insertion site. My preferred clinical regimen involves rubbing topical gel onto the tissues, using a cotton wool roll, followed a minute later by LA delivery with the needle inserted *obliquely* (at a sloping angle to the surface) into the insertion site mucosa (Fig. 5.11). Direct injection avoids more generalised infiltrations or blocks and hence patient discomfort. This often requires less than 0.2ml of LA per site, and it provides both rapid anaesthesia and a vasoconstrictive effect (which is useful if soft tissue is to be removed).



Figure 5.11 Local anaesthesia being injected directly into the insertion site soft tissues, with the needle at an oblique angle, on the mesial aspect of the maxillary second molar (where the first molar is absent).

LA is more effective in thick mucosa, plus the appearance of soft tissue blanching indicates that the insertion may proceed immediately.

The key principle is that the mucosa and periosteum are anaesthetised (remember bone doesn't have feelings), but the periodontal tissues of adjacent teeth remain responsive. This may alert the clinician if either the position or direction of the mini-implant needs to be altered during insertion because of close proximity to an adjacent dental root, or occasionally the opposite side of the alveolus. However some patients, especially anxious ones, may give false positive feedback, i.e. they over-interpret the pressure sensation as pain when the mini-implant is not actually approximating adjacent roots. This is also more likely in posterior mandibular sites, due to less alveolar elasticity with the higher cortical density. It is always helpful to percuss the adjacent teeth before the end of the insertion process: pain implies that the mini-implant is in close proximity to, or in contact with, the periodontal membrane. A dull percussion note indicates a limited width of alveolar bone between the mini-implant and tooth, but this is not an indication for re-insertion in the absence of percussion pain. Indeed, it is helpful to percuss the teeth before mini-implant insertion so that a baseline sound is noted. If in doubt, then a periapical radiograph, taken during the insertion process, should confirm whether the patient's sensation is accurate or not. If necessary, the mini-implant can be re-inserted at a different site or angle. If the insertion is clear of adjacent roots then further LA may be safely used to fully overcome any exaggerated patient discomfort.

Percuss the adjacent teeth before the end of the insertion process: pain implies that the mini-implant is in close proximity to, or in contact with, the periodontal membrane.

Antibacterial mouthwash

The patient should rinse the insertion site(s) for one minute using 0.2% chlorhexidine gluconate mouthwash. This helps to reduce the mucosal surface's bacterial levels immediately prior to insertion. It is also useful to give this bottle of mouthwash to the

patient for post-insertion use, in order to optimise hygiene compliance.

Stent application (optional)

'Free hand' insertion of a mini-implant is simple when there is ample interproximal space and the insertion site is easily accessible. In such cases it may help to highlight the middle of the interproximal space by vertically indenting the gingival surface, using the side of a dental probe, in a line running apical to the contact point. Otherwise, a surgical stent helps to guide the insertion instruments, ideally in all three dimensions. This does not need to be sterile, but it must be disinfected prior to use. For example, it may be helpful to initially soak a stent in chlorhexidine mouthwash for 10 minutes immediately before it is fitted in the mouth. Also remember that care should be taken to minimise contact of the mini-implant threads with the stent material as the insertion instrument is lined up in the stent's guidance channel.

It is important to ensure that the stent is both rigid and adequately stabilised during usage, e.g. by finger pressure on the occlusal surfaces of a removable one (Fig. 5.12). In addition, the screwdriver should not be leant on (pushed in one direction) whilst inside the guide cylinder. These precautions help to minimise flexing or movement of the stent and the subsequent risk of the screwdriver sticking in the stent when it is being released from the mini-implant. This arises because of a conflict between the paths of mini-implant insertion and screwdriver removal, when the stent has been moved or flexed.



Figure 5.12 A manual screwdriver placed within the stent's buccal guidance cylinder. The stent's baseplate is being stabilised by finger pressure on its occlusal surface.

It is important to ensure that the stent is both rigid and adequately stabilised during usage.

Soft tissue removal

Use a soft tissue punch (mucotome) where the insertion is through either (thick) palatal attached tissue or through unattached/mobile buccal mucosa. The mucotome tip is positioned perpendicular to the tissue surface and simultaneously rotated and pressed through the soft tissue, using either a manual screwdriver handle or contra-angle handpiece. Once the bone surface has been contacted, the punch is rotated against it to cleanly incise the circle of soft tissue (Fig. 5.13). The excision can be completed by removing the tissue plug with a curette or mosquitoes forceps. When a stent is used it is best to provisionally indent the mucosa with the mucotome inserted in the guidance cylinder, and then temporarily remove the stent so that the mucotome can be applied perpendicular to the tissue surface and hence provide a consistent tissue cut. Finally, it is important for an orthodontic assistant to hold a slow suction tip close to the tissue punch site since the cut tissue edge will bleed until the mini-implant neck seals the site.

Cortical perforation

Full pilot drilling (of both cortical and cancellous bone layers) is required for non-drilling mini-implants but not for self-drilling designs. However, even self-drilling insertions benefit from perforation of the cortical plate where it is dense and thick, e.g. the posterior

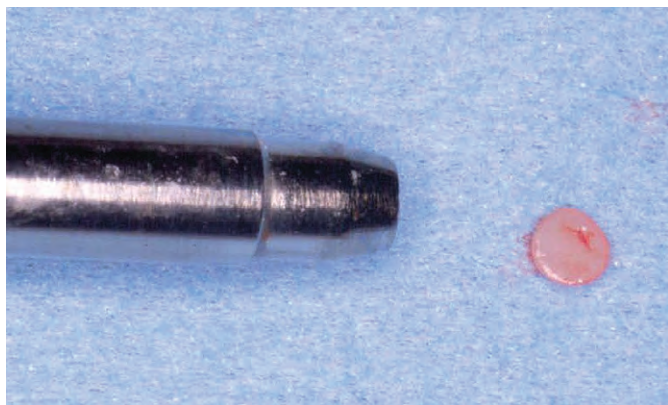


Figure 5.13 The circular piece of excised attached mucosa is seen adjacent to the Infinitas soft tissue punch (mucotome) used to remove it.

mandible and palate (both mid-palate and alveolus) areas. Crucially this involves making only a 1–2 mm perforation of the cortex (Fig. 5.14) in contrast to an 8–10 mm pilot drilling depth. In effect, cortical perforation facilitates mini-implant insertion by reducing the risks of screw fracture and excessive insertion torque (which compromises secondary bone healing). In addition, some clinicians like to use a cortical punch to indent the cortex at many more insertion sites in order to provide a locating ('purchase') point for the mini-implant tip. This is especially useful to prevent slippage on the bone surface, where the alveolus has a convex contour and an oblique insertion is planned.

Cortical perforation may be performed with either a pilot drill, partially inserted into bone, or a customised bone punch. The latter have the advantage of a shoulder at the end of the drill section, which limits the drilling depth (Fig. 5.14). Such punches may be used either manually, in the manner of a screwdriver, or with a contra-angle handpiece. As with a mucotome, the cortical punch is rotated under axial pressure in order to penetrate the cortex. However, this can be a surprisingly quick and simple process

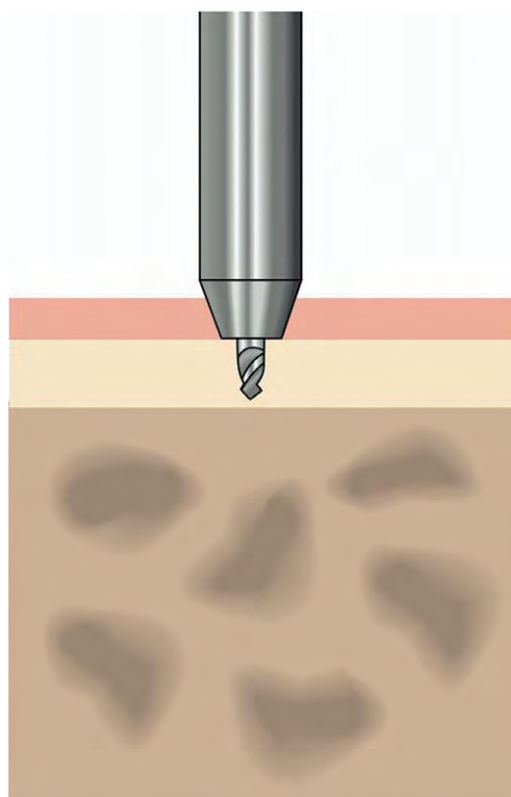


Figure 5.14 Diagram of the Infinitas cortical bone punch traversing the mucosa and inserting into a thick cortical layer.

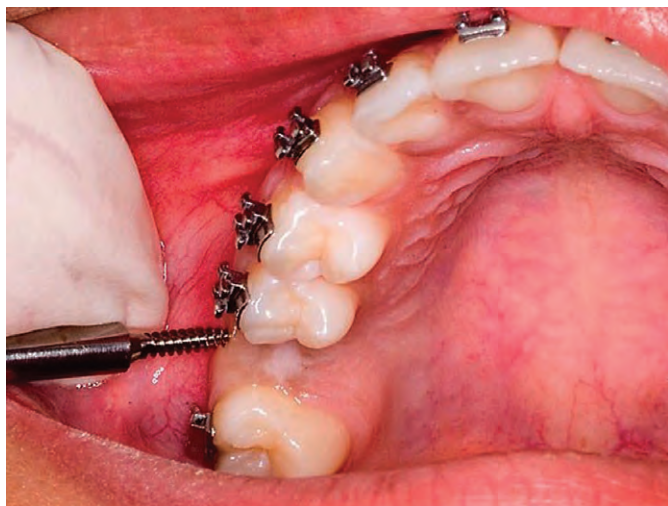


Figure 5.15 Free-hand manual insertion of a 2.0mm diameter mini-implant in the right maxillary edentulous molar site. The adjacent cheek and buccal sulcus are held taut (with finger pressure) to provide access and to prevent the loose mucosa from wrapping around the mini-implant threads.

since even manual perforation takes only a few seconds. Crucially, the punch should be directed at the planned insertion angles rather than at right angles to the surface (which differs from the mucotome application).

Mini-implant insertion

The screwdriver should be fully engaged onto the mini-implant neck or head (depending on the type of implant design), but without excessive pressure since this may make it more difficult to subsequently detach the screwdriver. If there is doubt over whether the implant is securely engaged then shake the screwdriver over a sterile field to ensure that the mini-implant does not fall out.

A self-drilling mini-implant may be inserted directly through thin mucosa and into the bone (Fig. 5.15), except in situations requiring preliminary perforations of the mucosa and/or cortex. Even when the cortex is initially perforated, insertion of a self-drilling mini-implant still continues in the normal manner. The insertion may be performed using a manual or handpiece-driven screwdriver. The former is recommended for buccal sites, since it gives the operator tactile feedback and fine motor control. A contra-angle slow handpiece is used where direct access is limited, e.g. palatal or posterior buccal sites (Fig. 5.16). I prefer using a customised cordless



Figure 5.16 Handpiece insertion of an Infinitas mini-implant on the palatal aspect of the alveolus, where the end of the screwdriver insert fits within the 3D stent. The mini-implant's body can be seen through the plastic guidance cylinder.

mini-implant handpiece which is capable of: precise slow speed control (e.g. 25 revolutions per minute, to control the insertion depth and heat generation), providing a digital reading of the maximum insertion torque (in lieu of a tactile indication of this) and presetting the maximum torque below 30Ncm (in order to avoid root injury and excessive bone strain). Alternatively one may use a speed reduction handpiece (with at least a 128:1 ratio) coupled with reduction of the dental unit's motor speed (e.g. from 40 000 to 10 000rpm). This limits the maximum screwdriver speed to below 100rpm, whilst still delivering adequate insertion torque. Unfortunately if insertion is attempted by solely reducing the dental chair/motor speed (and using a normal 1:1 or 4:1 ratio speed reduction handpiece) then there is a strong risk of inadequate torque delivery and the handpiece may stall mid-insertion.

Even when the cortex is initially perforated, insertion of a self-drilling mini-implant still continues in the normal manner.

The mini-implant is inserted slowly by rotating the screwdriver handle clockwise with one's fingers and with firm seating pressure at the base of the handle. It is essential that one's wrist is stabilised and that the

rotations are produced by digit movements alone. Remember it is a gentle procedure for both the patient and their bone. Care should also be taken not to alter the insertion angle during this process. Firm pressure is used initially to penetrate the cortical plate, applied by pressing the palm on the end of the manual screwdriver at the same time as rotating it. The insertional resistance tends to reduce once the first few threads appear to be submerging, and then the insertion process should continue solely by rotational means. As the mini-implant is gradually advanced into bone then the torque (resistance to screwdriver rotation) tends to increase, especially in posterior mandible sites and with a tapered body design, e.g. the 1.5mm diameter Infinitas version (as the wider section of body engages the cortex). Excessive resistance, usually felt as difficulty in turning a manual screwdriver by finger pressure alone (without resorting to rotation of the wrist), may result in either implant fracture or delayed bone necrosis. In such circumstances the insertion should either be paused for 10 to 20 seconds (allowing time for the viscoelastic nature of bone to allow its expansion around the mini-implant), or the mini-implant should be unscrewed by one to two anti-clockwise turns before inserting it further with clockwise rotations. These measures may be repeated as necessary until the desired final insertion depth is approached (but do not derotate at the final insertion stage).

As the mini-implant is gradually advanced into bone then the torque (resistance to screwdriver rotation) tends to increase.

It is crucial to avoid over-inserting a mini-implant, either by leaving an insufficient amount of the head exposed (for orthodontic attachment purposes) or by rotating it beyond the point of continued engagement in the bone (when it continues to rotate freely but without inserting more deeply). Equally a mini-implant should never be partially unscrewed in an attempt to increase its emergence profile, since this will inevitably result in a loss of stability. Therefore, it is best to control the final insertion stage by slowly rotating the screwdriver clockwise until the desired body insertion depth or head emergence profile is reached. It is often helpful to detach the screwdriver at this stage in order to visually inspect the remaining exposed mini-implant



Figure 5.17 The long (manual) screwdriver insert is being detached from the mini-implant head after removal of the screwdriver handle. The end of the insert is held by two fingers in order to avoid lateral displacement and facilitate detachment in line with the mini-implant's long axis.

threads and head-mucosa distance. When detaching the screwdriver care should be taken to avoid excessive lateral or pull-out movements. In particular, if substantial pressure was required to penetrate the cortex then this may result in noticeable resistance to the first detachment attempt. Whilst it is very tempting to tug the screwdriver laterally, this must be avoided since it may conflict with the mini-implant's path of release from within the screwdriver, resulting in the widening of the mini-implant bed or even its fracture. Therefore, it is advisable to reduce the chances of lateral 'tugging' by first detaching the screwdriver handle (or handpiece). It is then easier to pull the screwdriver component off the mini-implant in a straight line, along the long axis of the implant-screwdriver, by grasping the insert's end with a forefinger and thumb grip (Fig. 5.17).

It is best to control the final insertion stage by slowly rotating the screwdriver clockwise until the desired body insertion depth or head emergence profile is reached.

If primary stability, indicated by the final insertion torque and initial implant firmness to touch, is unsatisfactory then the mini-implant should be removed and the insertion process repeated at a different site. If a sudden increase in torque is

experienced and/or the patient reports pain in an adjacent tooth (especially on percussion of the tooth) then close root proximity is a distinct possibility. If this is suspected then take an intra-oral radiograph to check the mini-implant position in relation to adjacent structures, and re-position it if necessary. In the case of a re-insertion, a cortical punch should be used if the mini-implant tip has become blunted and does not easily penetrate the cortex. If an adjacent suitable site is not available at the same clinical appointment then allow a minimum of eight weeks before repeating the insertion in the same site. It may also be helpful to diverge (separate) the adjacent tooth roots, if their close proximity is the problem, before attempting re-insertion.

Mini-implant fracture

Fortunately this is an infrequent occurrence, typically associated with excessive torque due to either insertion in high density bone, contact of the mini-implant with a tooth root or deviation of the insertion path (when the mini-implant is already partially inserted). In the case of root contact one would expect the patient to feel pain, but this may not occur if the level of anaesthesia has affected the periodontal membrane as well as superficial tissues.

Most mini-implant fractures occur flush with the cortical surface, leaving the retained fragment submerged and difficult to retrieve. Provided that the mini-implant is manufactured from a titanium or titanium alloy material then it can be left in situ, to be covered over by soft tissue healing, if the orthodontist is confident that it won't interfere with any remaining tooth movement or cause root trauma. However, if it is necessary to remove the retained fragment so that a new mini-implant can be inserted, or if an adjacent tooth needs to move towards this site, then a small surgical procedure is required. This involves elevation of a muco-periosteal flap and trephination of a narrow trough of bone around the fragment so that an instrument, such as a Weingart plier, can be used to unscrew it. Given that a surgical flap is required many orthodontists will prefer to advise the patient of the problem immediately after the fracture and then refer the patient to a surgical colleague for this procedure at a later date.

Post-operative instructions

It is advisable to provide the patient with both verbal and written instructions on post-insertion analgesics (usually only taken in the first 24 hours),

chlorhexidine usage and advice not to fiddle with the mini-implant or touch it with an electric toothbrush. 'Traditional' oral hygiene advice was that chlorhexidine mouthwash should be used twice daily for five days. However, in order to prevent tooth staining a more ideal long-term option is for the patient to dip a small manual toothbrush into the chlorhexidine and brush daily and gently around the mini-implant head in order to inhibit peri-implant tissue inflammation or hyperplasia.

Force application

Most mini-implant types can and should be loaded immediately, unless the final insertion torque was very low, i.e. there was minimal screwdriver resistance on final seating. As a rule of thumb, it is advisable that only a light (approximately 50g) force is applied for the first six weeks, especially in adolescents. This is easily applied by a gently stretched elastomeric chain, and it allows time for the bone healing response to stabilise the mini-implant. Subsequently, various kinds of attachments, e.g. preformed nickel titanium coil springs and elastomeric chains, can be placed for direct loading with conventional continuous orthodontic force levels, e.g. 200g. Care should be taken to avoid derotational effects on directly loaded mini-implants since an anti-clockwise movement may result in a reduction in secondary stability.^{3,4} Conversely, a clockwise rotational movement may enhance stability over time. This secondary detail can be utilised for mini-implants with a bracket-like head design, such as Infinitas, by placing an elastomeric chain around the external circumference to be rotationally neutral, or by attaching a coil spring on the wing (corner) that is most likely to cause subtle clockwise rotation of the head (Fig. 5.18).

As a rule of thumb, it is advisable that only a light (approximately 50g) force is applied for the first six weeks.

Indirect anchorage loading may also be applied immediately via an auxiliary wire (ligature or rigid wire) either connected to the fixed appliance or simply bonded to an adjacent tooth. The latter scenario may utilise a cross-tube on the main archwire and intermediary rectangular steel wire, as illustrated in Chapter One.



Figure 5.18 The mini-implant has been loaded by direct connection of a closing coil spring on a wing of its head. The spring is ligated to a fixed appliance powerarm to retract the anterior teeth.

Biomechanics

It is now clear that fixed appliances can exert more profound three dimensional effects, especially in the vertical direction, when mini-implants are utilised. Therefore, customised mechanics are required in order to maximise the desired effects and minimise side-

effects. These details are discussed in relation to specific clinical scenarios in the following chapters.

Explantation

Mini-implants are removed once the need for anchorage reinforcement has abated, although if there is any doubt over future anchorage requirements they can easily be left in situ and unloaded for several months. This gives the orthodontist the option of turning anchorage on and off. In contrast, can you imagine convincing a patient to recommence wearing headgear after you had given them the 'all clear'? Since mini-implants do not osseointegrate in terms of clinical ankylosis they are easily removed, usually without the need for local anaesthesia. The exception to this occurs in cases with submerged mini-implant heads or in the upper labial area where soft tissue sensation may be heightened. Explantation is performed by fully engaging the screwdriver (both manual and handpiece versions) onto the mini-implant and rotating it anti-clockwise. Rotate the implant fully out of its socket, without pulling it out since this causes pain due to the threads catching on the peri-implant soft tissue. No special post-removal precautions (e.g. suturing or analgesics) are required, and both the soft tissues and bone heal uneventfully (the former within several days).

A summary of mini-implant insertion steps

1. Case selection: identify the anchorage requirements
2. Records & planning: obtain records (+/- a working model for stent fabrication)
 - obtain informed consent
 - determine the insertion site & timing
 - fabricate a stent as required
 - select optimum mini-implant dimensions
3. Mini-implant insertion: superficial anaesthesia (blanch the mucosa)
 - chlorhexidine mouthwash for 1 minute
 - fit stent (if applicable, pre-soaked in chlorhexidine)
 - soft tissue removal – if site is in thick or loose mucosa
 - perforate cortex—for posterior mandible and palate sites in adults
 - insert mini-implant with slow steady screwdriver rotations
 - if torque is high then pause for 10–20 seconds or partially derotate
 - percuss adjacent teeth to gauge implant–root proximity
 - if root proximity apparent then take a radiograph or re-insert implant
4. Post-insertion: apply light (e.g. 50g) traction for the first six weeks
 - provide verbal & written patient instructions and mouthwash
5. Explantation rotate mini-implant anti-clockwise until fully removed

Maximising mini-implant success: ten clinical tips

1. Gain experience with manually performed buccal insertions before attempting palatal insertions (with a contra-angle handpiece). This helps develop a feel for manual control and insertion torque.
2. Direct or indirect anchorage: identify the ideal insertion site (in terms of anatomical and biomechanical considerations) and the type of attachment to the fixed appliance at the treatment planning stage.
3. 'Develop' the insertion site (interproximal space) by diverging the adjacent roots during initial fixed appliance alignment. This is achieved by altering the tip of adjacent brackets, e.g. adding mesial bracket tip in order to mesially tip an upper second premolar crown.
4. Use a guidance stent, especially if you are inexperienced with mini-implants or not the treating orthodontist, but also for difficult to access (e.g. palatal) insertion sites.
5. Use superficial anaesthesia, at least until the risk of root proximity has been discounted, so that live patient feedback from adjacent periodontal membranes is available.
6. Don't over-insert the mini-implant: it will be prone to tissue overgrowth and/or will loosen if subsequent partial derotation is attempted.
7. Always apply light (circa 50g) traction for the first six weeks, or even leave unloaded in adolescents where the insertion torque has been low.
8. Correct minor secondary (delayed) mobility of a mini-implant by simple further clockwise rotation by one to two turns (without the need for anaesthesia).
9. Apply antero-posterior traction to a powerarm on a rigid stainless steel archwire. This will reduce intrusive side-effects and maximise bodily movement of the target teeth.
10. Insert mini-implants in palatal and mid-palatal sites for maximum intrusion and distalisation effects, respectively.

References

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Incisor Retraction

When most orthodontists think of anchorage it is probably a scenario involving the use of an intra-oral appliance or headgear to stabilise the maxillary molars during retraction of the anterior teeth. Unsurprisingly, this was one of the first identified applications for mini-implants, with traction applied directly from the mini-implant (typically inserted buccally between first molar and second premolar roots), sparing molar involvement and hence anchorage loss. Both clinical experience and published studies have shown that mini-implant usage enables orthodontic treatment goals to be more fully realised, in terms of full incisor retraction without anchorage loss, than the traditional gold standard of headgear anchorage.^{1,2,3,4,5,6,7,8} Indeed, anchorage *gain* has been observed whereby the maxillary molars have been distalised by the continuation of traction after closure of the premolar spaces. In addition, intrusive side-effects on the molars may assist with Class II correction, due to favourable mandibular counter-clockwise autorotation (measured as a reduction in the mandibular plane angle and an increase in the SNB angle). Therefore, it appears that mini-implant anchorage produces both substantial anchorage effects and also (somewhat unexpectedly) fixed appliance biomechanical side-effects which are different and more multi-dimensional than those effects observed with conventional anchorage. For example, if traction is applied directly to a canine bracket, with a steep vertical direction (vector) and with a flexible archwire in situ, then pronounced distal tipping of the canine causes a 'rollercoaster' buckling of the buccal segment (Fig. 6.1). Similarly, if a steep

vector of traction is applied to the labial segment, with a rigid archwire in situ, it may cause the side-effect of clockwise rotation of the entire maxillary arch and consequently molar intrusion (Fig. 6.2). Therefore, in average and deep overbite cases, mini-implant traction should be applied parallel to the occlusal plane (with a horizontal vector) by crimping a powerarm (an elongated vertical hook) on to the anterior part of the archwire (Fig. 6.3). This minimises the rotational effect on the whole arch and also produces more favourable bodily retraction of the anterior teeth (than can be achieved with conventional biomechanics) because the traction is applied closer to their centres of rotation.^{3,8,9,10} Finally, unlike conventional anchorage options, mini-implants also offer both direct and maximum anchorage reinforcement in the mandibular arch.

In average and deep overbite cases, mini-implant traction should be applied parallel to the occlusal plane by crimping a powerarm onto the anterior part of the archwire.

Clinical objective

- Prevention of mesial movement of the upper or lower molars during retraction of the anterior teeth for overjet reduction and/or centreline correction.

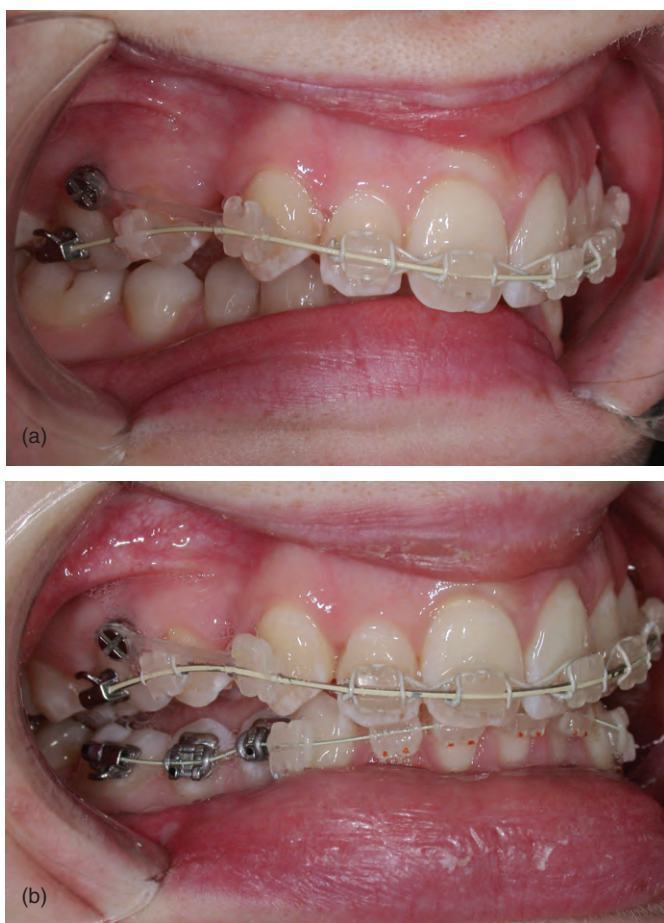


Figure 6.1 Alveolar necking in the right maxillary first premolar extraction site, resulted in very difficult distalisation of the adjacent canine in this adult patient. Consequently, elastomeric traction applied from the mini-implant to the upper canine bracket caused (a) distal tipping of the canine and a rollercoaster bowing of this 0.018 NiTi archwire, then (b) molar intrusion when traction continued on a rigid archwire.

Treatment options

- Direct bone anchorage by applying traction from a mini-implant inserted in the posterior alveolus, in either jaw.
- Indirect alveolar bone anchorage using a mini-implant to stabilise the posterior teeth (the dental anchorage unit) e.g. by a ligature from the mini-implant to an anchor tooth (Fig. 6.4).
- Indirect bone anchorage (maxillary arch only) using mid-palate mini-implants.
- Conventional anchorage, e.g. headgear, transpalatal arch, lingual arch.

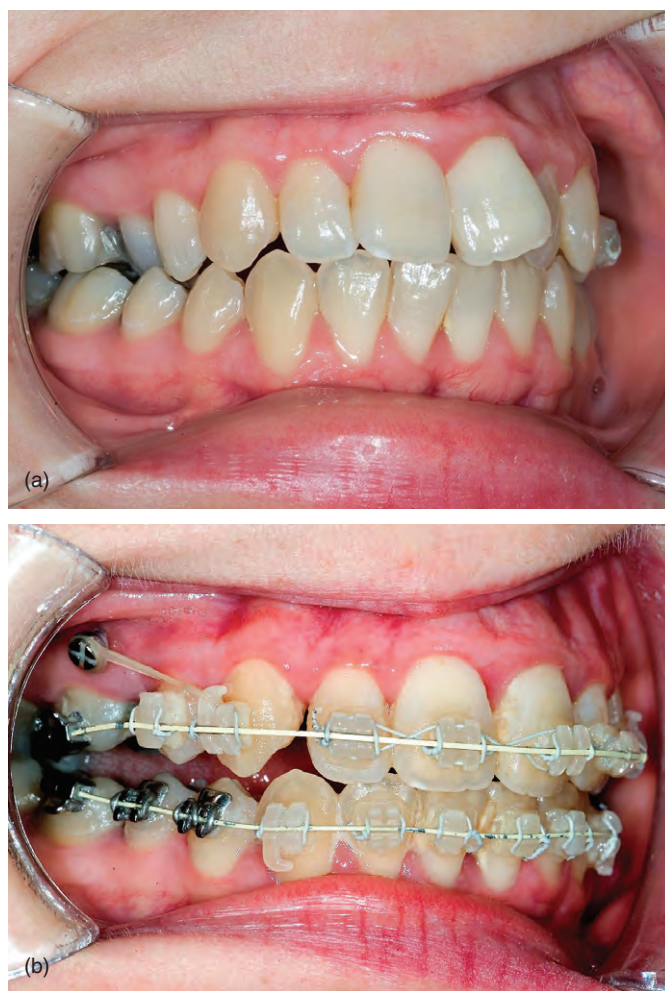


Figure 6.2 (a) This adult patient had extraction of the upper right second premolar for canine and incisor retraction. (b) The steep vector of elastomeric traction applied from the mini-implant to the upper canine bracket, although with rigid archwires in place, caused intrusion of the adjacent first molar, premolar and canine teeth. However, this was partially favourable in this case because of the reduced overbite, although the second molar should have been included for the full benefit of this vertical side-effect.

- Intermaxillary elastics for indirect anchorage.
- Correction of the skeletal base (negating the anchorage requirements) using orthognathic surgery or orthopaedic (functional) appliance treatments.

Key treatment planning considerations

- The anchorage requirements, as indicated by the overjet, incisor inclination, distance that the canines need to be retracted into Class I (allowing for any

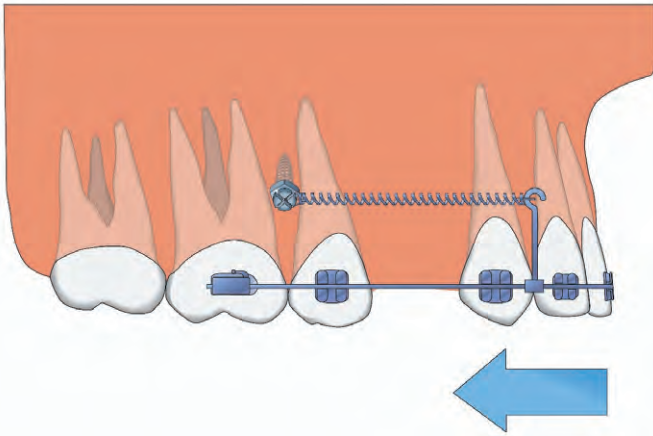


Figure 6.3 Diagram of a horizontal vector of traction from the posterior mini-implant to a powerarm fixed on the anterior archwire, causing bodily retraction of the anterior teeth (without molar intrusion).

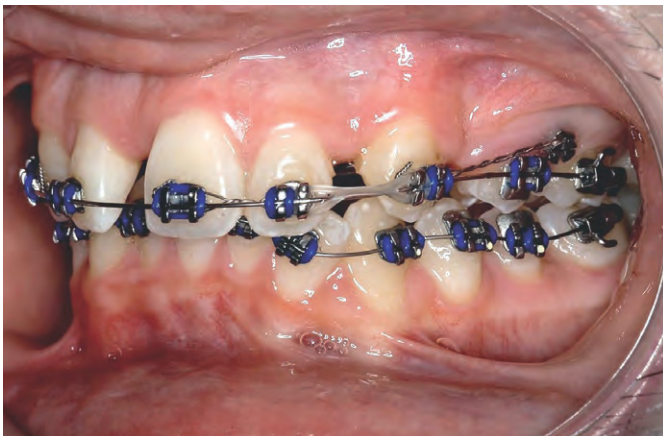


Figure 6.4 Indirect anchorage using a stainless steel ligature from the posterior mini-implant to the canine bracket, enabling active traction from this canine to retract the adjacent incisors (in this adolescent patient with an absent upper right central incisor).

canine movements in the opposing arch), buccal segment relationships and extraction pattern.

- Overbite: this affects the ideal vertical level of the mini-implant and the vector of traction, i.e. the more apical the position of the mini-implant head then the more potential for molar intrusion in a reduced overbite case.
- Centrelines: is there a need for asymmetrical incisor retraction?
- Morphological or prognostic differences between the posterior teeth which may influence the extraction

pattern, e.g. loss of a restored or macrodont/microdont second premolar may be indicated rather than a virgin first premolar even if this increases the anchorage demands.

- Is there sufficient interproximal space between the first molar and second premolar roots, or is preliminary root divergence required?
- The amount of incisor crowding: is there a need for preliminary canine retraction to enable incisor alignment (prior to overjet reduction)?
- If there is insufficient primary stability in buccal alveolar sites (in adolescent patients) then consider using the mid-palate as a source of indirect anchorage. For example, two short length and wide diameter mini-implants (e.g. Infinitas 6mm length, 1.5 or 2 mm diameter) may be inserted in para-sagittal positions and used to anchor the Nance button of a transpalatal arch (TPA). This stabilises the upper molar anchor teeth, but there is a risk of anchorage loss if the TPA bends due to insufficient rigidity. There are also clinical time and additional (laboratory) cost implications due to the need for fabrication of a customised TPA or Nance arch, plus traction can only be applied at the coronal level from the molar hooks.

Biomechanical principles

- Increased overbite case: consider adjunctive intrusion of the anterior teeth using additional anterior mini-implants.
- Reduced overbite case: bond the second molars (if fully erupted) during the alignment phase so that they can be actively intruded during space closure, by virtue of the rotational effect of oblique traction on the arch. The molars may be further intruded by direct vertical traction after the space closure phase.
- Determine the ideal traction vector prior to mini-implant insertion. For example, if there is sufficient height of attached gingiva then the mini-implant may be vertically sited at a relatively apical level, but with the potential effect of producing an oblique (steep) vector of traction and consequently molar intrusion (Fig. 6.5a). Conversely, if there is only a narrow band of attached gingiva then the mini-implant is limited to a coronal insertion level, resulting in closer proximity to the archwire plane and a relatively horizontal line of traction (Fig. 6.5b).
- The force vector may also be altered by application of the traction to a powerarm: an elongated hook

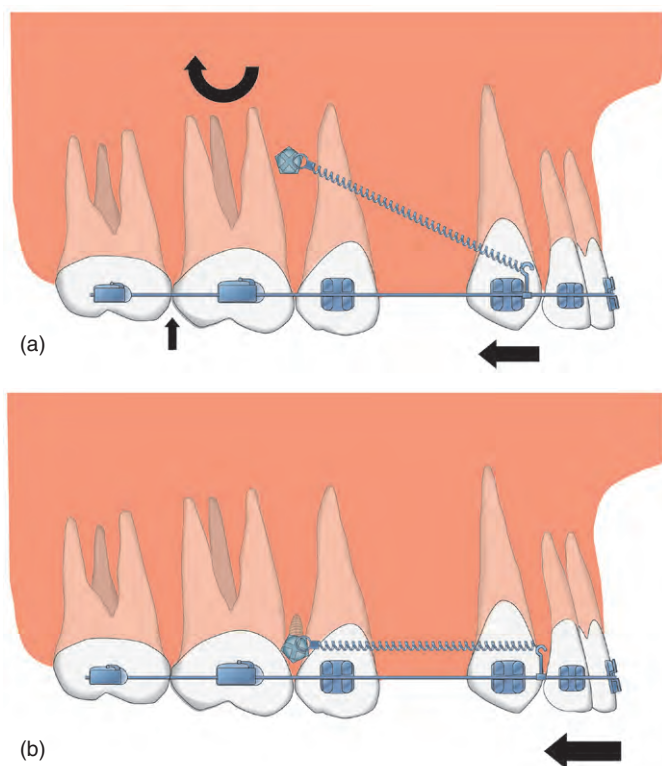


Figure 6.5 Diagrams of a buccal mini-implant inserted at (a) apical and (b) coronal levels resulting in oblique and horizontal vectors of traction respectively.

attached to the archwire or a bracket (Fig. 6.3). This has three effects/uses:

- Elimination of the vertical component (vector) of the traction since the powerarm enables traction to be attached at the same vertical level as the mini-implant head. This minimises the risk of inadvertent molar intrusion, due to clockwise arch rotation.
- The powerarm facilitates more bodily retraction of the incisors since the traction is applied closer to the centre of rotation of the anterior teeth.
- A single tooth powerarm is also very useful for controlled canine retraction in cases requiring space for relief of incisor crowding (Fig. 6.6). This greatly assists bodily canine distalisation and reduces the risk of the rollercoaster phenomenon (Fig. 6.1) due to distal tipping of the canine, even when a flexible archwire is in place.
- Indirect anchorage, e.g. utilising a bone anchored TPA, involves force application on the fixed



Figure 6.6 An adult patient (a) presenting with a Class II division 1 malocclusion with severe crowding of the upper labial teeth, requiring maxillary canine distalisation prior to incisor alignment and retraction. (b) A powerarm hook soldered to the canine bracket enables bodily retraction of this tooth on a 0.018 steel archwire, which in turn facilitates simultaneous alignment of the adjacent lateral incisor using a 0.012 piggyback NiTi wire. (c) The canine has been retracted within two months such that a 0.012 NiTi archwire can be fully ligated.

appliance molar hooks. This means that biomechanical effects are similar to conventional straight wire approaches.

The powerarm facilitates more bodily retraction of the incisors since the traction is applied closer to the centre of rotation of the anterior teeth.

Mid-treatment problems and solutions

- Vertical side-effects such as a lateral openbite and excessive incisor retroclination (Figs 6.1, 6.2):
 - Avoid the application of traction with a flexible archwire in situ and when a working stainless steel archwire (e.g. 0.019×0.025) has not fully levelled the arch.
 - Add a bite-opening curve to the working archwire.
 - Accept the openbite discrepancy until anchorage is no longer required, then remove the mini-implants, bond the second molars and use a flexible archwire to level the arch.
 - Vertical settling elastics may also be added, although most lateral openbites readily settle once traction has ceased and the archwire changes are expressed (Fig. 6.7).

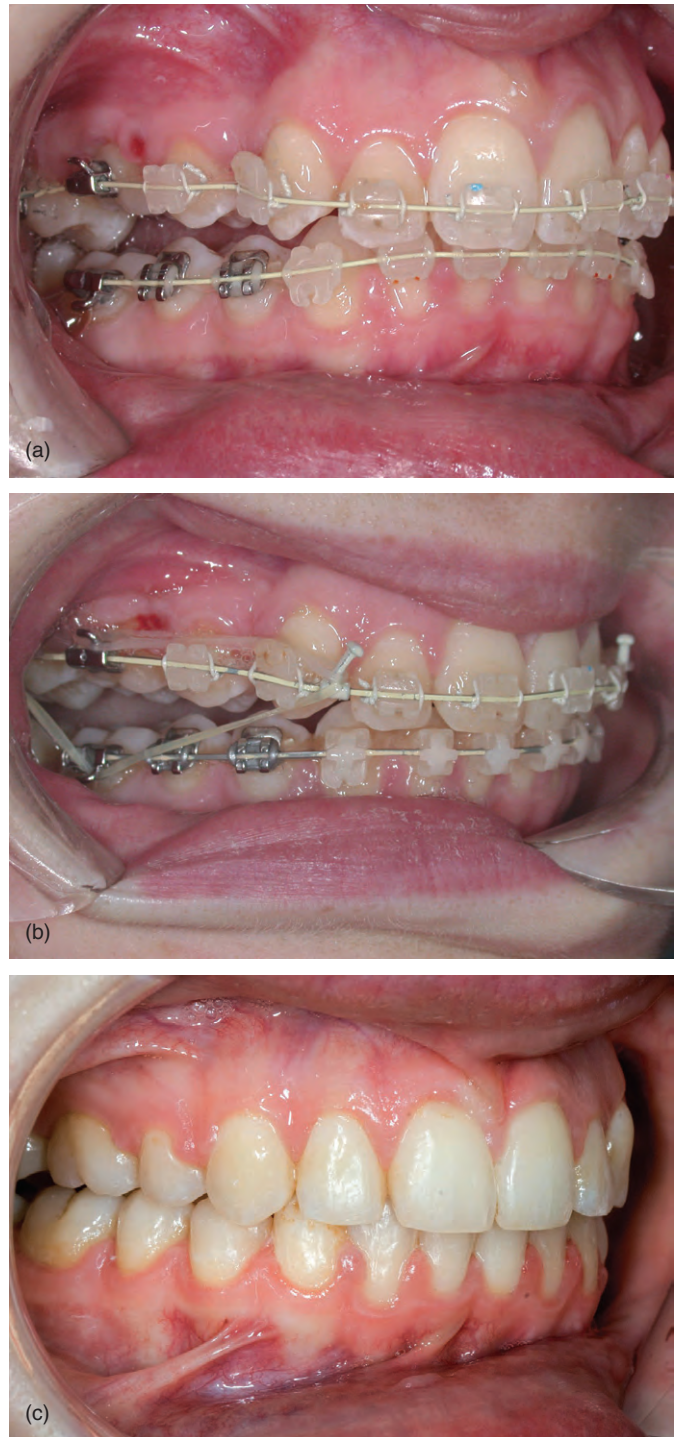


Figure 6.7 The patient shown in Figure 6.1 after (a) removal of the mini-implant and bonding of the upper second molar to assist with levelling. (b) An upper 0.019×0.025 NiTi archwire is combined with a triangular elastic to settle the lateral openbite. (c) Debond view.

Posterior mini-implant clinical steps*Pre-insertion*

1. Increase the interproximal space available at the insertion site(s) by bonding the attachments on the first molar and second premolar crowns at altered tips, e.g. add mesial tip to the premolar bracket, causing the root to move mesially during initial alignment.
2. If initial canine retraction is indicated then align most of the arch to be ready for a 0.018 stainless steel working archwire and add a powerarm to the canine crown or bracket. Otherwise, for en masse retraction, align and level the whole arch to be ready to accommodate a 0.019 × 0.025 steel archwire.
3. If desired, have a stent fabricated by taking an impression of the arch two weeks pre-insertion. Avoid waxing out brackets and the buccal sulcus near the insertion site and record the clinical level of the mucogingival junction.

Mini-implant selection

4. Maxilla: use a narrow long body, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 9mm length, short neck version).
5. Mandible: use a narrow, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 6 or 9mm length, short neck version). The length selection depends on the anticipated cortical depth and density such that a long length is selected in adolescent patients or if angulated insertion is indicated (because of limited attached gingival height).

Insertion

6. Identify the ideal buccal alveolar insertion point, through attached gingivae (which does not require a soft tissue punch step), and between the second premolar and first molar roots.
7. Superficial anaesthesia of the insertion site.
8. Determine the angles of insertion. All mini-implants are inserted into the interproximal space and generally perpendicular to the surface in the horizontal plane. Maxillary mini-implants may be inserted at either 90° (perpendicular to the surface) or angled obliquely by up to 30°, by inclining the screwdriver in an apical direction (Fig. 6.8). Oblique insertion angles in the mandible tend to be less, e.g. 10°, since the cortex is denser and there is frequently more posterior interproximal space available (due to the root morphology).
9. Manual insertion is recommended where there is sufficient physical access (including ease of stretching of the cheek and buccal sulcus). Otherwise handpiece insertion may be performed, but with resultant loss of full tactile control.
10. A cortical bone punch is recommended as the first step for posterior mandibular sites (except in adolescent patients, who have less dense cortex).
11. Complete the insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible. This is best performed gradually and with intermittent release of the screwdriver during the final turns, so that over-insertion is avoided.
12. Percuss the adjacent teeth to gauge root proximity and take an intra-oral radiograph if a problem is suspected.

Post-insertion

13. For initial canine retraction apply traction directly from the mini-implant head to the canine bracket/hook.
14. For en masse labial retraction crimp a powerarm to the archwire mesial to the canine bracket (Fig. 6.3). If necessary, adjust the level of traction on the powerarm to create a horizontal line of traction (parallel to the occlusal plane).
15. Immediately load the mini-implant with *light* traction for the first 5–6 weeks, e.g. a lightly stretched powerchain. Subsequently apply normal levels of traction using a NiTi closing spring or elastomeric auxiliary.

16. If an increase in overbite is indicated then add vertical traction from the mini-implant to the archwire, or to both molar and premolar attachments, to cause direct intrusion of the posterior teeth. This may require archwire contraction to avoid buccal crown flaring and arch expansion.
17. Discontinue the traction and consider explanting the mini-implant once the anchorage requirements have been met, e.g. Class I canines and incisors.
18. If a lateral openbite has developed then (after explantation) bond the upper second molars and level the arch using a flexible NiTi archwire (Fig. 6.7). Vertical/box elastics may also be used to settle the buccal occlusion.

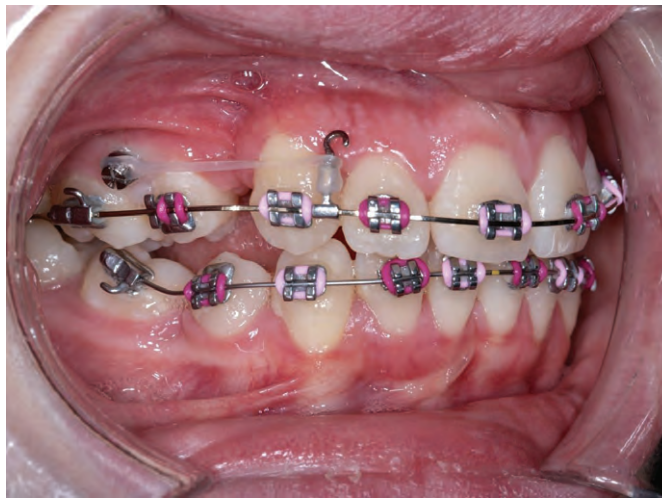


Figure 6.8 An adult patient with limited height of attached gingiva at the upper right buccal insertion site, requiring oblique (apical) inclination of the mini-implant. Horizontal traction to the labial segment is achieved with a powerarm, featuring a composite resin stop to prevent coronal slippage of the traction auxiliary.

CASE EXAMPLES**1. Increased overbite (Fig. 6.9)**

- An adult male with a Class II division 1 malocclusion on a mild skeletal II base (Fig. 6.9a).
- The original 15mm OJ was reduced to 8mm during initial alignment (to reach a 0.019 × 0.025 steel archwire stage).
- Upper first premolars were extracted.
- 1.5mm diameter, 9mm length, short neck mini-implants were inserted in buccal positions mesial to the upper first molars and immediate traction was applied to powerarms (Fig. 6.9b).
- The mini-implants were explanted once Class I canine and incisor relationships had been achieved (Fig. 6.9c).
- No sign of the insertion sites were evident at debond. Indeed no peri-implant inflammation occurred despite chronically substandard oral hygiene (as evident from the gingival hyperplasia) (Fig. 6.9d).

2. Anterior openbite (Fig. 6.10)

- A 14 year old female with a Class II division 1 malocclusion on a moderate skeletal II base with a 6mm OJ and a 9mm AOB (Figs 6.10a–e). She refused orthognathic surgery in favour of attempted orthodontic camouflage treatment, accepting that this would not significantly correct her Class II profile.
- An upper fixed appliance was bonded and after initial alignment the AOB had reduced to 5mm. The upper first premolars were then extracted for camouflage treatment to continue.
- 1.5mm diameter, 9mm length, short neck mini-implants were inserted in buccal positions mesial to the upper first molars and immediate traction was applied to powerarms (Figs 6.10f, g). The traction was then applied directly to the canine brackets to provide an oblique vector and hence simultaneous molar intrusion.
- Lower second premolars were extracted once it was clear that full correction of the malocclusion was feasible with orthodontic camouflage. The lower fixed appliance was bonded and progressed onto space closure in both arches (Fig. 6.10h).
- Elastomeric traction was applied directly to the maxillary molar and second premolar attachments for direct buccal intrusion to continue substantial reduction of the AOB after the incisors had been retracted (Figs 6.10i, j).
- Final AOB closure was achieved following adjunctive use of palatal mini-implants (1.5mm diameter, 9mm length, long neck versions), inserted distal to the first molars (Fig. 6.10k).
- Treatment was completed with a reduced overbite feature maintained, to allow for incisal edge augmentations, and a small amount of over-correction of the molar intrusion. Whilst a Class II facial profile was still evident, there was more definition of the soft tissue pogonion and more easily achieved lip competence (Figs 6.10l–o).

3. Indirect palatal anchorage (Fig. 6.11)

- A 13 year old boy presented with a Class II division 1 malocclusion on a mild skeletal II base, with bimaxillary proclination and associated bilabial protrusion (Fig. 6.11a). He had a 9mm OJ, a deep OB and impacted lower second premolars, necessitating earlier extraction of the lower first premolars (Figs 6.11b–d).
- The upper first premolars were extracted and an upper fixed appliance bonded. Insertion of a mini-implant was attempted initially on the buccal aspect of the maxillary alveolus, mesial to the upper first molars, but this was abandoned due to the low insertion torque. This poor primary stability is a recognised risk in young adolescent patients with immature cortices, so the mid-palate was elected as the optimum anchorage site instead.
- 1.5mm diameter, 6mm length, long neck mini-implants were inserted in para-sagittal sites, level with the upper premolars (Fig. 6.11e). These were inclined by approximately 30° towards the anterior nasal spine and inserted with a stent and contra-angle handpiece (in accordance with my standard mid-palate insertion regimen).

- The working model, with mini-implant analogues, was also used to fabricate a modified Nance palatal arch. This featured two holes in the button which corresponded to the planned mini-implant head locations. My first preference would have been for molar bands to have been used as part of the Nance arch, but this was not feasible in this case due to the macrodont size of the molar crowns. The Nance arch was seated, bonded to the first molars, and the gaps between the mini-implant heads and the acrylic base were obturated with light-cured composite (Fig. 6.11f).
- This indirect anchorage stabilised the maxillary molar teeth, enabling immediate elastomeric chain traction to be applied from the molar tubes to the canine brackets (Figs 6.11g–i).
- After five months of traction the canines had been retracted into Class I positions and the OJ reduced, without the loss of anchorage (Figs 6.11j–n). The lower arch was bonded at this stage. There were residual upper arch spaces and Class III molar relationships, which provided scope for subsequent Class III elastomeric traction (to retract the proclined lower incisors).



Figure 6.9 (a–e) Pre-treatment views of the Class II division 1 malocclusion, with full unit II canines, and the Class II skeletal relationship. (f–h) Mini-implant traction to powerarms commenced after initial alignment and extraction of the maxillary first premolars. ((g) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (i, j) Cephalogram and photographs taken immediately after en masse retraction of the labial segment, and at the time of the maxillary mini-implant removals. ((j) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (k–n) Debond views.

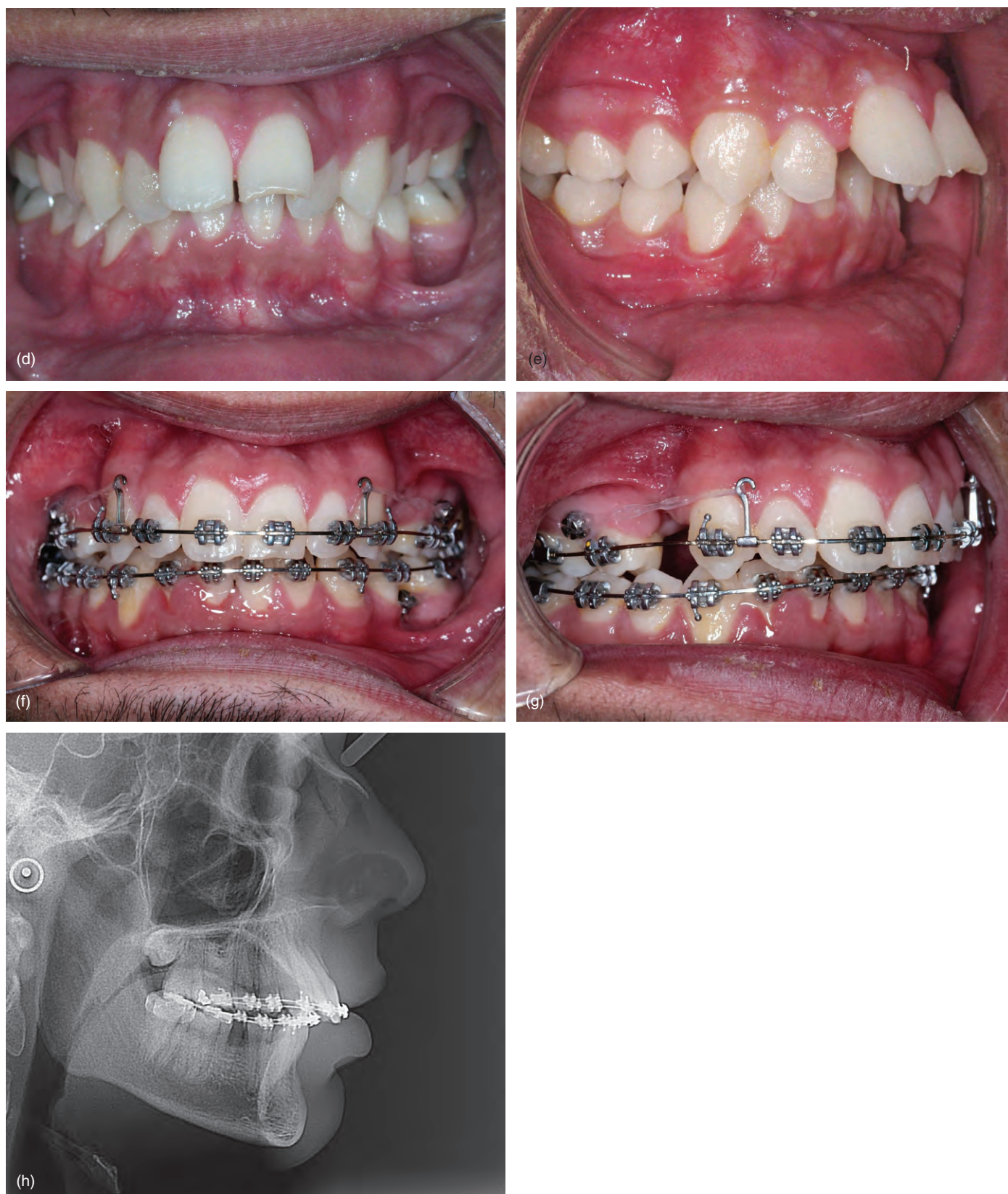


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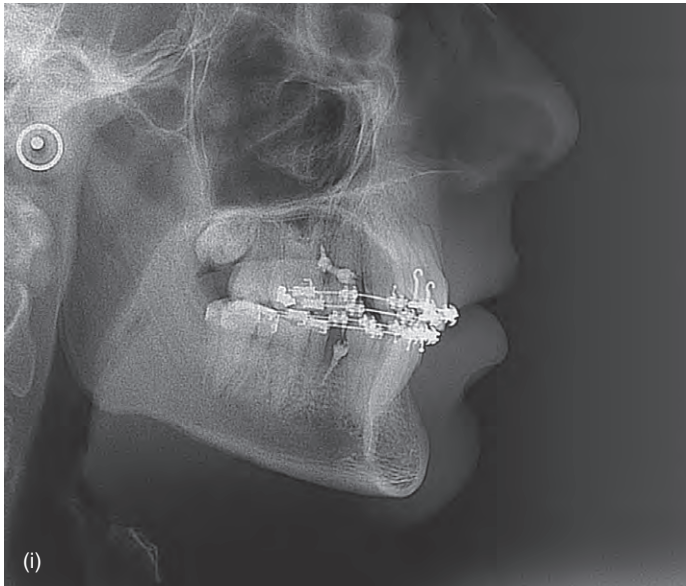


Figure 6.9 *Continued*



Figure 6.10 (a–e) Pre-treatment views showing the Class II division 1 malocclusion, moderate skeletal II base, reduced incisor display, lip incompetence, 9mm AOB and moderate anterior crowding. (f, g) The start of traction from maxillary buccal mini-implants to anterior powerarms, after extraction of the maxillary first premolars, levelling and alignment. (h) Oblique traction applied to the upper canine brackets and mandibular intra-arch space closure, following extraction of the lower second premolars and lower arch alignment. (i–k) Vertical traction applied to the maxillary second premolar and first molar crowns, and the start of adjunctive palatal mini-implant vertical traction. (l–o) Debond views, with a modest posterior openbite over-correction evident.

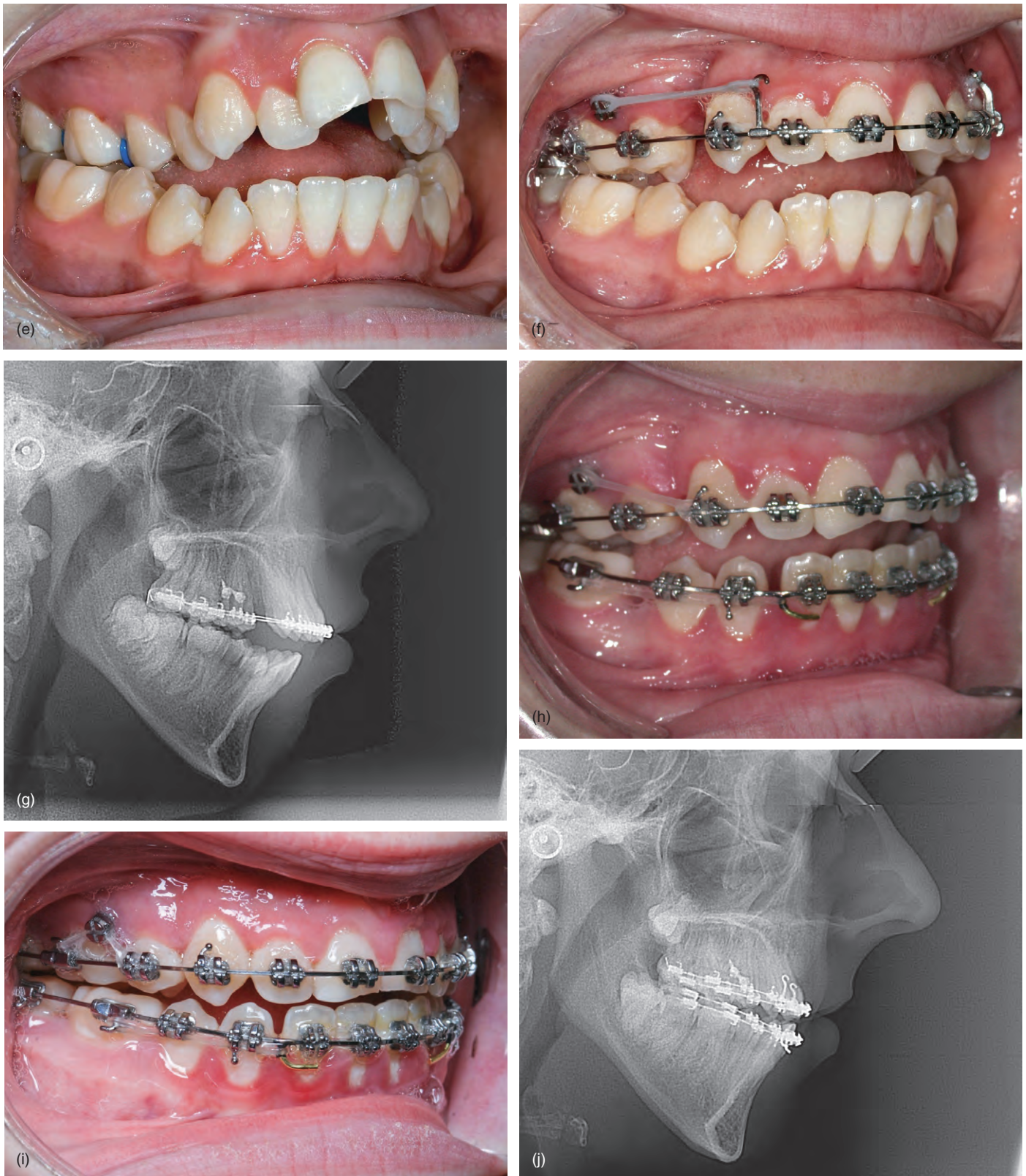


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Figure 6.10 *Continued*

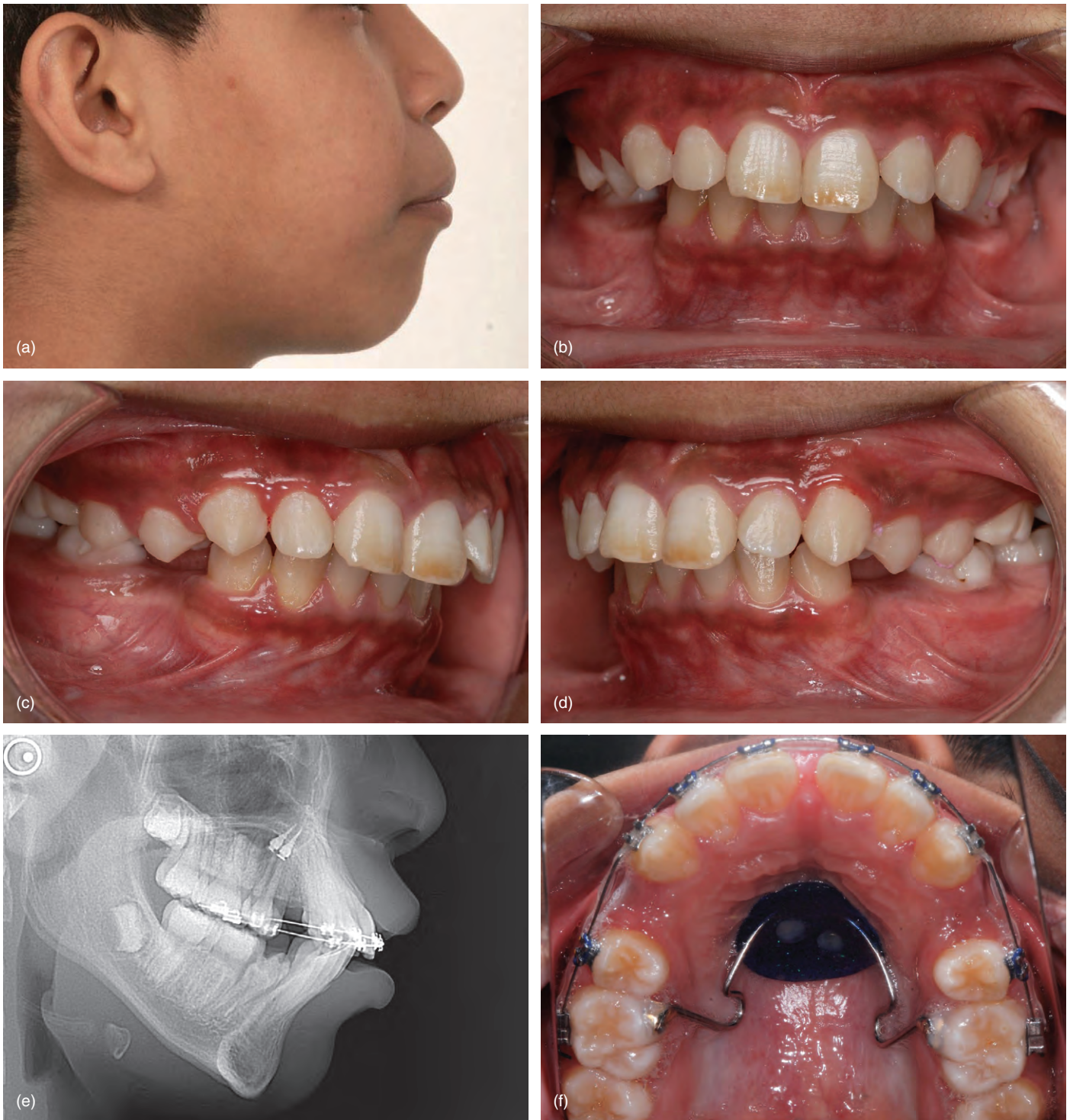


Figure 6.11 (a–d) Pre-treatment views showing the Class II division 1 malocclusion, with previous extraction of the lower first premolars to dis-impact the second premolars, and the convex lip and facial profile. (e–i) Views of the two 6mm length palatal mini-implants anchoring the modified Nance arch, after extraction of the maxillary first premolars and initial arch alignment. (j–n) The canine relationship is now Class I and the labial segment is being retracted using intra-arch elastomerics from the molar hooks.

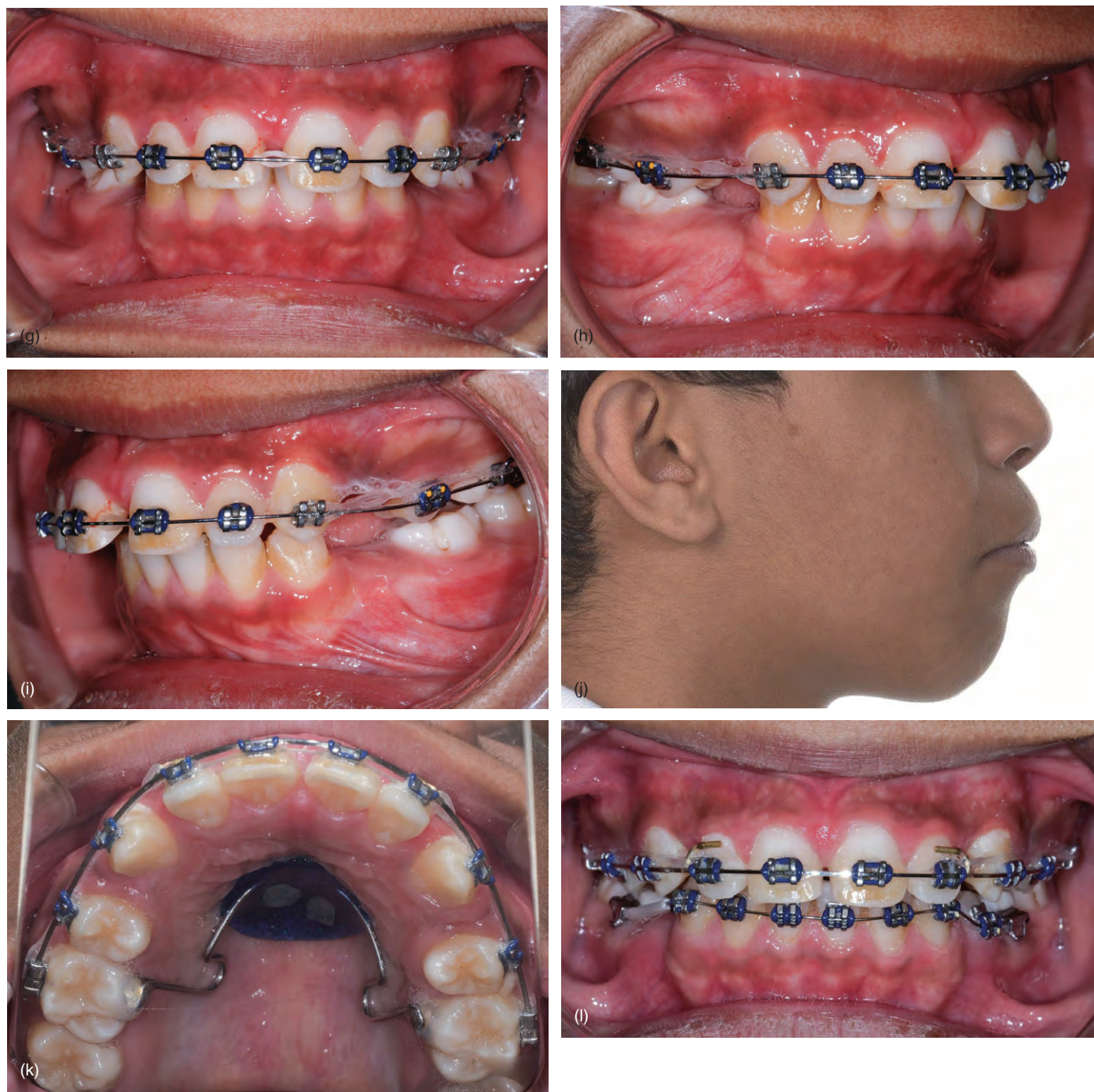


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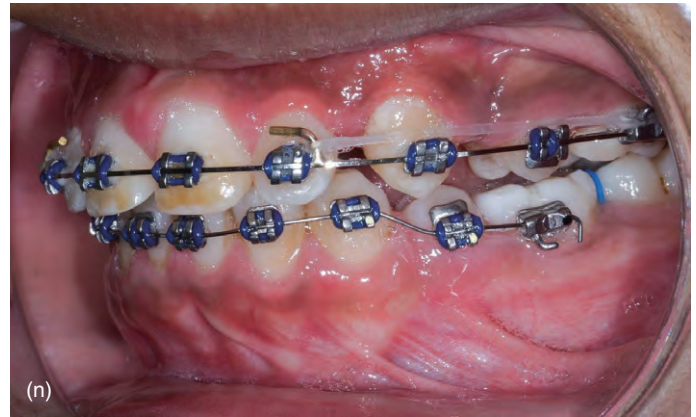
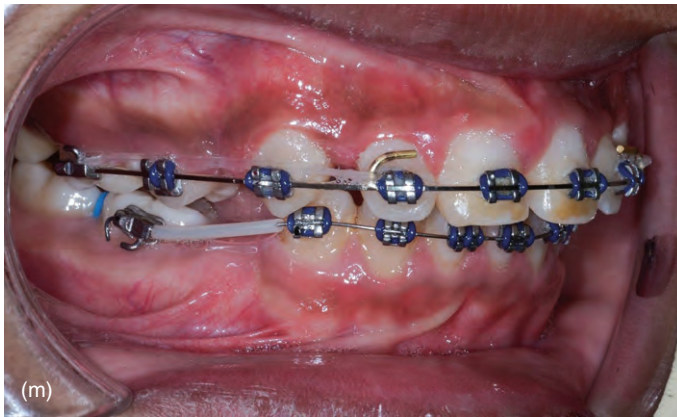


Figure 6.11 *Continued*

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Molar Distalisation

Whilst *buccal* mini-implants are relatively easy to insert, their interproximal position, in close proximity to the buccal roots of adjacent molar teeth, limits the amount of nearby tooth movement which may occur. Consequently buccal anchorage approaches provide only limited scope for molar distalisation and typically require a two phase distalisation process: initially for molar movement and secondly for retraction of the premolar and anterior teeth. Furthermore, the mini-implants need to be re-located between these two phases, risking anchorage loss during this switch-over process. Fortunately, the availability of the hard palate for bone anchorage substantially increases the options for upper molar distalisation. Therefore, the choice of mini-implant site depends on the planned amount of maxillary molar movement and on whether the mid-palate area is easily accessible (which may not be the case in high arched palate cases). For example, up to half a unit of distalisation may readily be achieved using direct traction from mini-implants sited in the *palatal* alveolus. A greater range of distalisation and probably better bodily control over the molars' movements are both achieved through indirect palatal anchorage of a customised distalserter appliance. Importantly, this differs from the use of 'non-compliance' distalisers since the incorporation of mini-implants avoids anchorage loss during both the distalisation and subsequent retraction phases, in the form of mesial movement/proclination of the anterior teeth and then molar anchorage loss.^{1,2}

Up to half a unit of distalisation may readily be achieved using direct traction from mini-implants sited in the palatal alveolus.

The options for distalisation of mandibular molars are limited to using anchorage sites in either the posterior alveolus (e.g. just mesial to the first molar) or the retromolar area. However, the latter site may be complicated by the presence of the third molar, difficult physical access and a lack of attached gingiva (a shallow buccal sulcus).

Clinical objectives

- Prevention of mesial movement of the premolars and anterior teeth during molar distalisation.
- Prevention of molar mesial movement (anchorage loss) during subsequent retraction of the anterior teeth.

Treatment options

- Buccal alveolar mini-implant anchorage (direct or indirect) in either arch.
- Palatal alveolar mini-implant anchorage.
- Mid-palate mini-implant distalserter.
- Premolar extractions (where none have previously been undertaken), avoiding the need for molar distalisation.

- Headgear, possibly with an upper removable appliance (e.g. a 'Nudger'), for upper molar distalisation.
- Correction of the skeletal base (negating distalisation requirements) by orthognathic surgical or orthopaedic appliance treatments.

Key treatment planning considerations

- The molar, canine and skeletal base relationships.
- Eruptive status of the second molars: there is less resistance to molar distalisation before eruption of the second molars, but also a greater tendency to molar tipping (rather than bodily movement).³
- Presence/absence of third molars: consider their removal (before orthodontics) if they are likely to interfere with distalisation.
- Absence of posterior teeth (due to previous extractions or hypodontia).
- Depth and shape of the palatal vault, i.e. a high arched palate makes access difficult for mid-palate insertion of both mini-implants and a distalserter.
- Distalisation distance required and whether this differs for each side of the arch.
- Avoid maxillary buccal alveolar insertions since there is very limited interproximal space for distal movement of adjacent roots past the mini-implant. Hence, this approach requires re-siting of the mini-implants after molar distalisation and before the second phase retraction of the premolar teeth.
- Sufficient interproximal space is available between the maxillary palatal roots for both insertion and up to half a unit distalisation of teeth (before the mini-implant is approximated by roots mesial to it).
- Mid-palate anchored distalisers require more initial clinical, and especially laboratory, time due to their fabrication and fitting requirements. However, once in situ they are simple to reactivate and provide the

best range for distalisation. They may also provide optimum bodily molar movements, followed by simple retraction of the anterior teeth.^{4,5,6,7,8}

Biomechanical principles

- Forces applied at the coronal level will tend to distally tip molars during distalisation, then risk anchorage loss as the molars upright during retraction of the anterior teeth.¹
- Distalising forces directed at the furcation level will produce molar bodily movement.¹
- First molars tend to distally tip when the second molars are unerupted.³
- There is a tendency to molar crossbites as the molars distalise. This is exacerbated when a rigid transpalatal arch (TPA) is used, or when insufficient compensatory transverse coordination is incorporated in the fixed appliance archwires or a distalserter appliance's wire frame.

Mid-treatment problems and solutions

- If there are signs of molar tipping then over-correct their distalisation, in anticipation of molar relapse during retraction of the anterior teeth.
- It may be necessary to accept buccal crossbites, especially if a rigid TPA is used, until after the anchorage requirements have been met. However, if alveolar mini-implants are being used for direct traction then arch coordination can be attempted, e.g. by expansion of the maxillary archwire.
- Patients should alert the orthodontist as soon as they become aware of the breakage of any components to prevent anchorage loss or unfavourable tooth movements.

Mandibular arch distalisation

This involves mini-implant insertion in either posterior interproximal sites or the retromolar area.

Clinical steps for mandibular distalisation*Pre-insertion*

1. Level and align the arch to be ready for the working archwire, e.g. a 0.019 × 0.025 rectangular stainless steel wire.
2. Determine the optimum insertion site, e.g. distal to the terminal molar (Fig. 7.1) or mesial to the first molar (Fig. 7.2), depending on the ease of access to the retromolar site and the available interproximal space, respectively. The retromolar site may not be suitable if the third molar is present or if it has been removed within the previous few months.
3. Consider fabrication of a stent, especially if the insertion site is difficult to access or deliberately close to a molar root, by taking an impression one to two weeks pre-insertion. The fixed appliance brackets may be blocked out with soft wax except those adjacent to the insertion site, and ideally the clinical level of the mucogingival junction should be measured or photographed.

Mini-implant selection

4. Select a narrow, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 6 or 9mm length, version). The length selection depends on the anticipated cortical depth and physical access (depth of insertion), e.g. a short length is appropriate in the buccal alveolus and a long length in the retromolar area.

Insertion

5. Identify the insertion point in either the retromolar (Fig. 7.1) or alveolar interproximal areas. The latter insertion should be made just mesial to the first molar roots to allow for subsequent distal movement of the adjacent premolar towards the mini-implant (Fig. 7.2). Ideally the insertion should be through attached gingiva, but if this is not feasible then plan to first use a soft tissue punch.
6. Superficial anaesthesia of the insertion site.
7. Determine the angle of insertion (in the vertical plane): an interproximal mini-implant is inserted perpendicular to the buccal surface, whereas a retromolar one is placed at a small oblique angle from the axial plane such that the head is slightly buccal to its body position.
8. Manual insertion is feasible where there is sufficient physical access, i.e. adequate stretching of the cheek and buccal sulcus. Otherwise contra-angle handpiece insertion is recommended, especially in the retromolar area, but with resultant loss of full tactile control.
9. Limited pre-drilling (e.g. using a cortical bone punch) is recommended prior to mini-implant insertion, except in adolescent patients with less dense mandibular cortex.
10. Complete the insertion to the point that the mini-implant neck is partially submerged but its head is fully accessible for traction purposes. This is best performed gradually and with intermittent release of the screwdriver during the final turns, so that over-insertion is avoided. If the cortex gives rise to high insertion torque then remember to offset this by partial derotation of the mini-implant (provided that more than 1 mm of insertion range remains).
11. Percuss the adjacent teeth to gauge root proximity and take an intra-oral radiograph if a problem is suspected.

Post-insertion

12. Immediately load the mini-implant with *light* traction for the first 5–6 weeks, e.g. a lightly stretched powerchain. Subsequently apply *direct* traction to either an anchor tooth or the archwire using a NiTi coil spring or elastomeric attachment (Fig. 7.2a), or alternatively *indirect* anchorage may be performed by connecting the anchor tooth and mini-implant with a ligature wire or traction auxiliary (Fig. 7.1b).

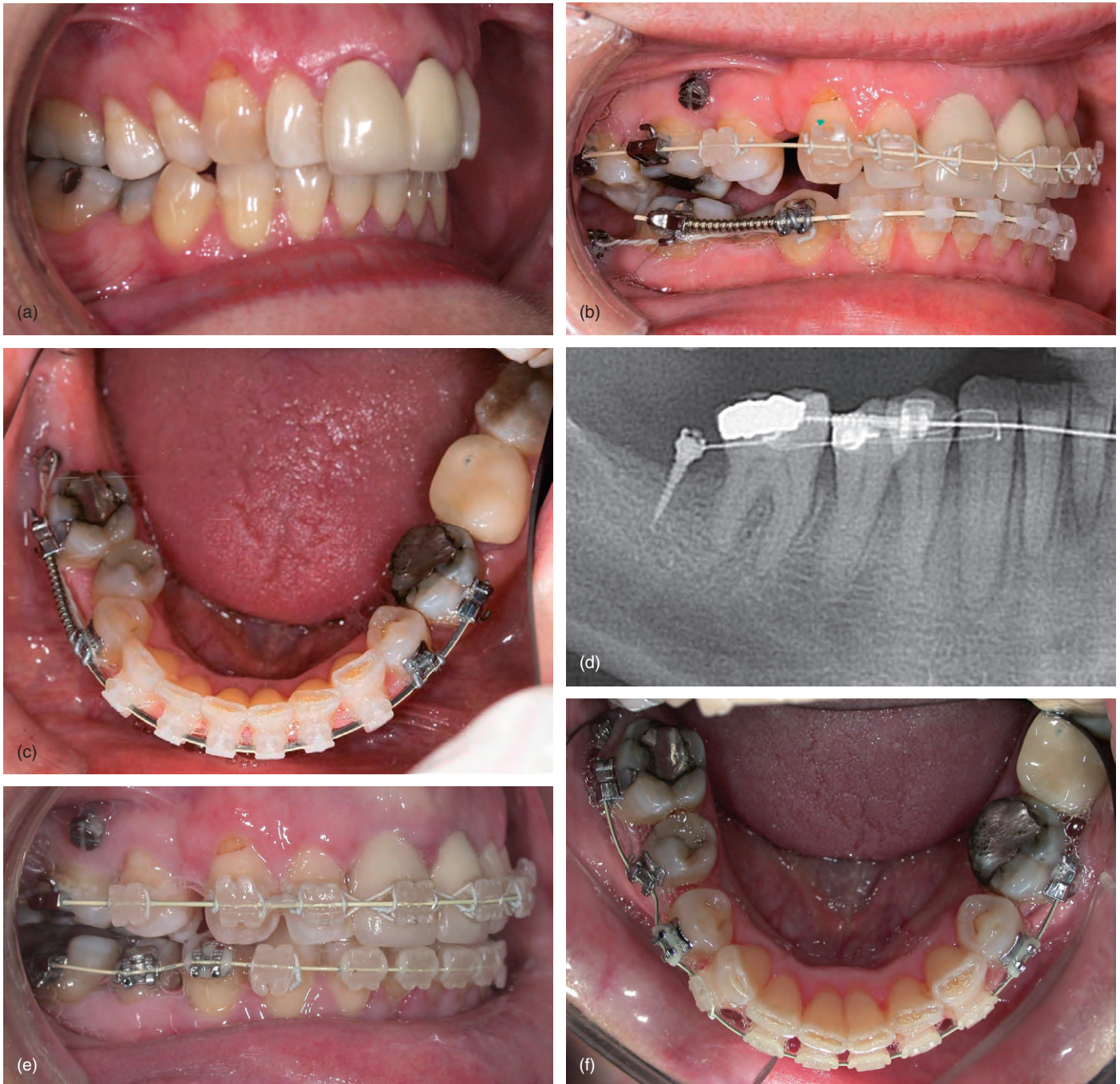


Figure 7.1 (a) Pre-treatment view showing the Class II malocclusion with absent lower right second molar, moderate crowding and lingual displacement of the lower right second premolar. (b–d) A mini-implant in the lower second molar site providing indirect anchorage using a ligature wire to the first premolar then canine brackets, whilst a compressed coil spring distalises the first molar. (e, f) Alignment of the second premolar after molar distalisation had created ample space.

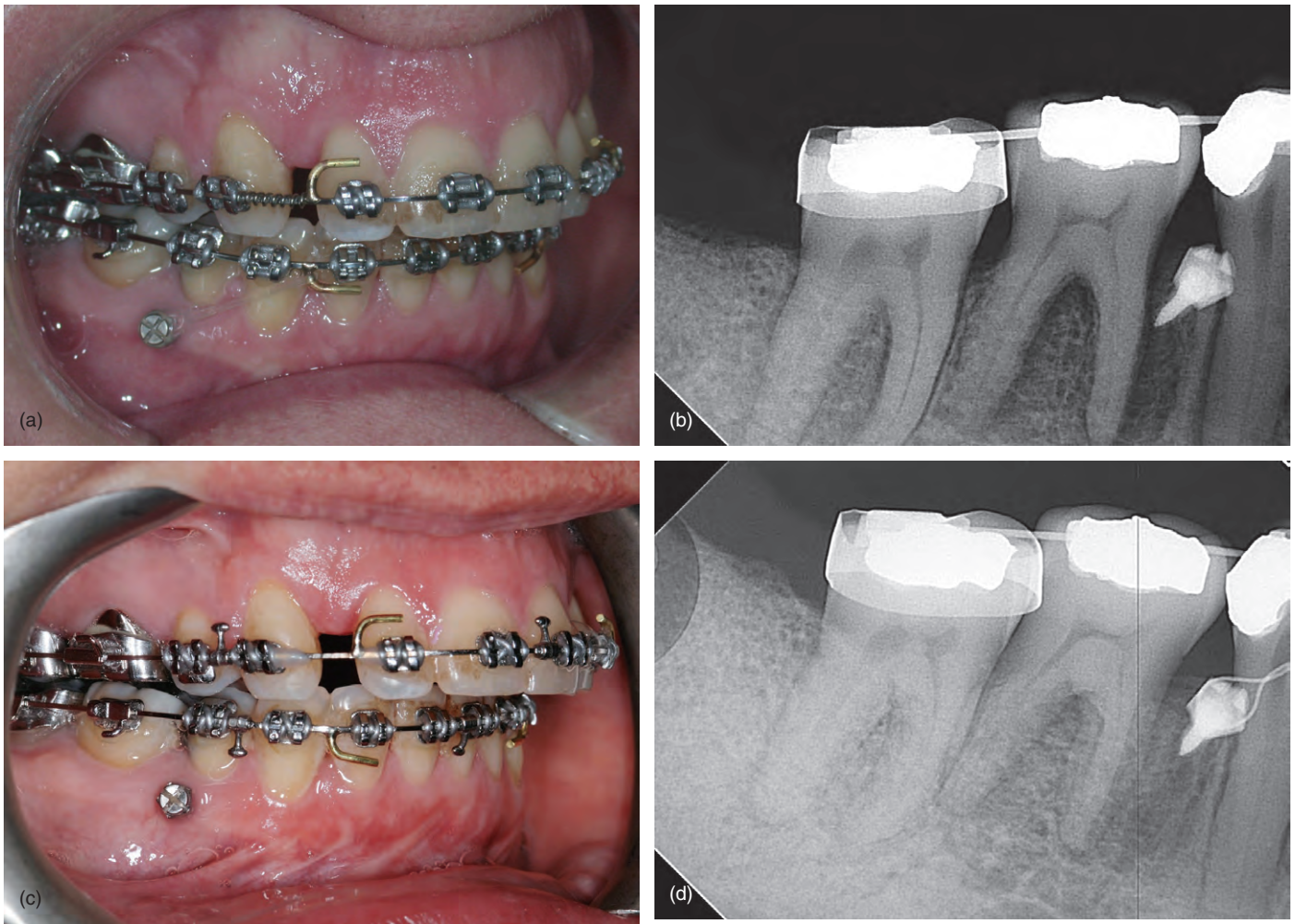


Figure 7.2 (a, b) Pre-surgical decompensation in this Class II case required incisor retraction, but the lower first premolars were already absent. These views show a mini-implant sited close to the right first molar root to provide sufficient range of arch distalisation before premolar–implant proximity occurs. Elastomeric traction applied to an archwire hook provides en masse retraction and a modest molar intrusive side-effect. (c, d) Traction completed prior to a mandibular osteotomy.

CASE EXAMPLES**1. Terminal mandibular molar distalisation (Fig. 7.1)**

- An adult with a Class II division 2 malocclusion with absent lower right second molar and lingual displacement of the lower right second premolar tooth (Fig. 7.1a).
- The lower arch, except the right second premolar, was aligned ready for insertion of a 0.019 × 0.025 steel archwire (Fig. 7.1b).
- A 1.5mm diameter, 9mm body length, long neck Infinitas mini-implant was inserted on the buccal aspect of the alveolar ridge and distal to the lower right first molar. It was used to indirectly anchor the right premolar then canine teeth (Figs 7.1b–d).
- Anchorage was discontinued once molar distalisation had created space for alignment of the second premolar (Figs 7.1e, f).

2. En masse lower arch distalisation (Fig. 7.2)

- An adult with a Class II division 2 malocclusion with absent first premolars, recent removal of the lower right third molar, and requiring incisor decompensation for a mandibular advancement osteotomy.
- Treatment commenced with arch alignment to accommodate a 0.019 × 0.025 stainless steel archwire, but with the lower first molars mesially tipped to increase the interproximal space on their mesial aspects (Fig. 7.2a).
- A 1.5mm diameter, 9mm body length, short neck Infinitas mini-implant was inserted mesial to the lower right first molar (Fig. 7.2b), and used to apply direct traction to a posted archwire.
- Anchorage was discontinued once en masse distalisation of the lower arch had occurred, but before the second premolar root approximated the mini-implant (Figs 7.2c, d).

Maxillary arch distalisation

The insertion site and biomechanics depend on the amount of distalisation required and mid-palate accessibility.

Clinical steps for palatal alveolar distalisation*Pre-insertion*

1. Band the first molars at the start of treatment if a TPA is planned for indirect molar distalisation.
2. Level and align the arch to be ready for a minimum of 0.018 steel archwire, but more typically a 0.019 × 0.025 rectangular wire.
3. Determine the optimum insertion site, e.g. mesial or distal to the first molar, depending on whether the second molars have erupted, arch length, the available interproximal space and ease of access.
4. Consider fabrication of a stent, especially if the insertion site is difficult to access or distally offset in the interproximal space (i.e. close to the more distal palatal root), by taking an impression one to two weeks pre-insertion. Note that the fixed appliance brackets may be fully waxed out (from a gingival direction) since the insertion site and stent coverage only involve the occlusal and palate surfaces.

Mini-implant selection

5. Use a relatively narrow mini-implant diameter, given the interproximal nature of insertion. The neck needs to be long enough to traverse the thick mucosa, e.g. for Infinitas use the 1.5mm diameter, 9mm body length, long neck version.

Insertion

6. Identify the palatal alveolar insertion point, just mesial to the first or second molar palatal root. This initially close proximity facilitates distal movement of the premolar/first molar before this root approximates the mini-implant.

7. Superficial anaesthesia of the insertion site.
8. Use a mucotome to remove a circle of mucosa from the insertion site.
9. Determine the angles of insertion. Palatal alveolar mini-implants are generally inserted perpendicular to the surface in the horizontal plane. In the vertical plane, they may be inserted at either 90° (perpendicular to the surface) or obliquely angled by inclining the screwdriver in an apical direction. This is appropriate to limit insertion depth if the palatal roots are relatively superficial.
10. A cortical bone punch (perforation) step is recommended in adult patients.
11. Contra-angle handpiece insertion is recommended because of the limited physical access, especially to avoid the path of insertion being angled towards the distal molar root (rather than horizontally neutral).
12. Complete the insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible. This is best performed gradually and with intermittent release of the screwdriver during the final turns, so that over-insertion is avoided.
13. Percuss the adjacent teeth to gauge root proximity and take an intra-oral radiograph if a problem is suspected.

Post-insertion

14. Direct traction: bond an attachment (a hook or modified powerarm) to the first premolar or canine tooth's palatal surface. A powerarm has the advantage of enabling a more horizontal vector of traction (Fig. 7.3). Indirect traction: fit a modified TPA (fitted on the first molars).
15. Immediately load the mini-implant with *light* traction for the first five to six weeks, e.g. a lightly stretched powerchain. Subsequently apply traction using a NiTi coil spring or elastomeric auxiliary.

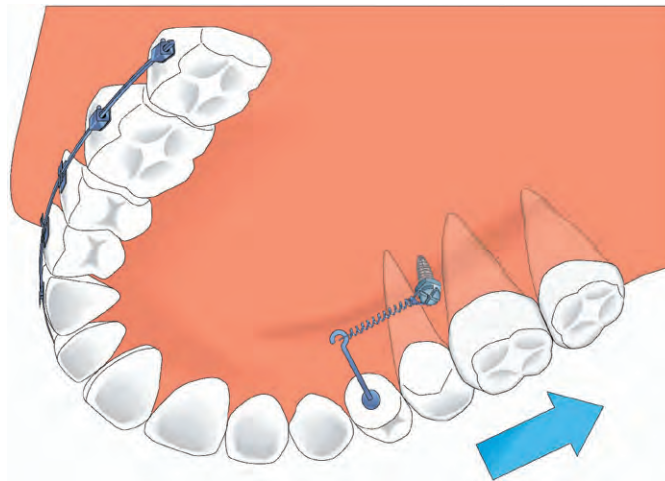


Figure 7.3 Diagram showing traction from a mini-implant, inserted in the palatal alveolus mesial to the first molar palatal root, to a powerarm bonded on the first premolar.

CASE EXAMPLES**1. Direct palatal alveolar traction (Fig. 7.4)**

- A 13 year old girl with a Class II division 1 malocclusion on a mild skeletal II base (Fig. 7.4a).
- The second molars were absent and the second premolars hypoplastic. The upper incisors had short roots (contra-indicating Class II intermaxillary traction).
- The overjet was 7mm and both the molar and canine relationships were asymmetrical: $\frac{1}{4}$ and $\frac{1}{2}$ unit Class II on either side.
- Upper fixed appliance alignment and levelling had been undertaken.
- 1.5mm diameter, 9mm length, long neck mini-implants were inserted mesial to the first molar palatal roots (Fig. 7.4b) and immediate traction was applied to the first premolars' palatal cleats (Fig. 7.4c).
- Up to half a unit of asymmetrical distalisation was achieved such that the premolar crowns approximated the mini-implant heads (Fig. 7.4d). The anterior teeth were retracted towards the premolars using indirect anchorage of the latter teeth.
- The mini-implants were explanted at debond (Fig. 7.4e).

2. Indirect palatal alveolar traction (Fig. 7.5)

- A 17 year old male with a Class III malocclusion on a severe skeletal III base, being prepared for orthognathic surgery. The maxillary first premolars were absent, but there was still severe crowding, impaction of the left canine and a substantial centreline shift to the left side (Figs 7.5a, b).
- More than half a unit bilateral molar distalisation was required. The palate was narrow and deeply vaulted, contra-indicating mid-palate mini-implant insertions.
- The first molars were banded at the outset and upper fixed appliance alignment and levelling was undertaken.
- 1.5mm diameter, 9mm length, long neck mini-implants were inserted palatal and mesial to the upper first molars then a modified TPA was fitted (Fig. 7.5c). Immediate traction was applied to bilateral hooks soldered on the anterior part of the TPA.
- The TPA was replaced during distalisation when its lateral aspects overlapped the mini-implant heads. The new TPA provided further clearance and traction distance, using an anterior mid-line hook (Fig. 7.5d).
- The second TPA was removed pre-operatively once sufficient space had been created for the absent canine tooth and centreline correction (Figs 7.5e, f). Cephalometric superimposition (Fig. 7.5g) shows the extent of molar distalisation and only modest incisor proclination.



Figure 7.4 (a) Lateral view showing a Class II malocclusion with a 7mm OJ and asymmetrical Class II buccal segment relationships, following removal of hypoplastic second molars and surgical exposure then alignment of the unerupted maxillary central incisors. (b, c) Views of the mini-implants, inserted mesial to the first molar palatal roots, and traction to first premolar palatal cleats. (d) The second premolar *crowns* appear close to the mini-implant heads following premolar and molar en masse distalisation. (e) Lateral view two years after debond.



Figure 7.5 (a, b) Pre-treatment views showing the severe Class III malocclusion, absent upper first premolars and impacted upper right canine. (c, d) Two palatal alveolar mini-implants, inserted mesial to the first molars, with elastomeric traction applied to two consecutive and differing designs of modified TPA. (e, f) Sufficient space created for the impacted canine following bilateral molar distalisation and centreline correction. (g) Cephalometric superimposition of the pre-surgical orthodontic changes (red pre-treatment, green pre-surgery) showing the molar distalisation achieved, without extrusion.

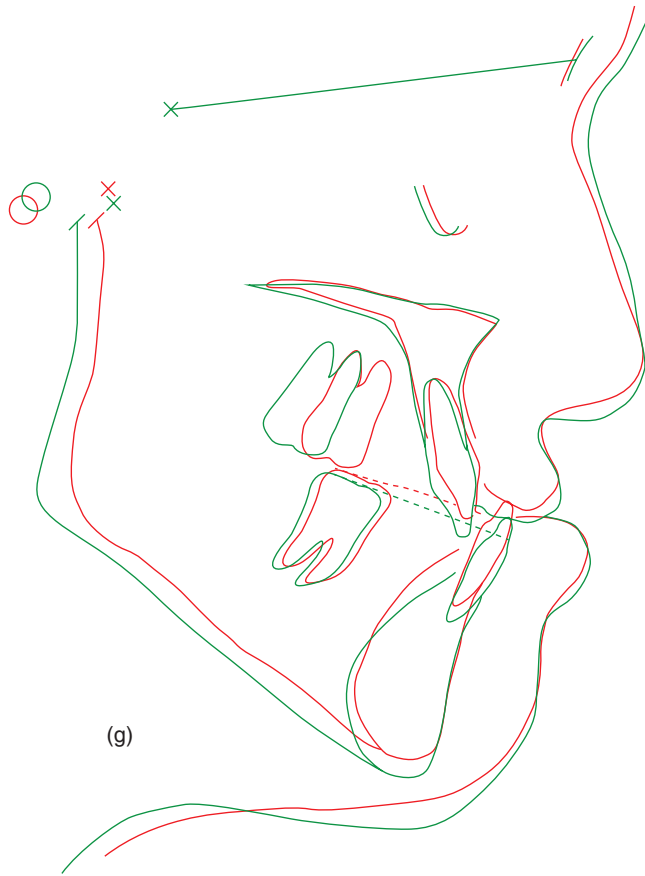


Figure 7.5 Continued

SKELETAL			SOFT TISSUES		
SNA	°	-1.5	Lip Sep	mm	-2.0
SNB	°	-0.5	Exp UI	mm	1.0
ANB	°	-1.0	LS-E	mm	0.0
SN/MxP	°	-2.0	LI-E	mm	0.0
MxP/MnP	°	3.0	NLA	°	8.5
LAFH	mm	4.5	LLA	°	-7.5
UAFH	mm	-1.0	Holdaway	°	-0.5
LAFH/TAFH %		2.0			
LPFH	mm	2.5	NOSE PROMINENCE		
UPFH	mm	-1.0	Nose tip	mm	-2.5
PFH	mm	1.5	Nose angle	°	-5.0
Wits	mm	-3.5			
TEETH			CHIN PROMINENCE		
Overjet	mm	-0.5	Chin tip	mm	-3.5
Overbite	mm	0.5	B-NPo	mm	0.0
UI/MxP	°	-3.0	LADH	mm	0.0
LI/MnP	°	1.5			
IIangle	°	-1.5			
LI-APo	mm	0.5			
LI-NPo	mm	0.5			

Mid-palatal distaliser options

A mid-palate anchored distaliser has the distinct advantage that the mini-implant positions will not limit molar and premolar tooth movements, but it is technically more demanding in terms of appliance design and insertion. Essentially there are two strategies to choose from: the use of pushcoil springs, on the distaliser frame, to push the molars distally (Fig. 7.6a); or the application of traction from a posterior hook to a sliding tube, to pull the molar back (Fig. 7.6b). The key advantages and disadvantages of each approach are summarised as follows.

Pushcoil distaliser

This design has the advantage of using conventional nickel titanium pushcoil as its active component, but this limits the diameter of the distaliser wire frame (to

0.7 mm or less) and hence its rigidity, resulting in potential anchorage loss due to flexing of the frame. It also means that the distaliser frame fits loosely into headgear tubes (soldered on the palatal sides of the molar bands), resulting in incomplete rotational control of the molars.

On the other hand the small frame diameter (e.g. 0.019 × 0.025 rectangular wire or round wire with 0.7 mm or less diameter) does offer the chance to engage it directly into the mini-implant heads (Fig. 7.6a), avoiding contact of the distaliser on the soft tissue (and hence its inflammation). However, this requires accurate laboratory fabrication and perhaps what is more challenging is the need to level and align the mini-implant heads (especially their cross-slots) to enable the distaliser frame to be seated. Finally, the pushcoil needs to be reactivated by the use of a Gurin

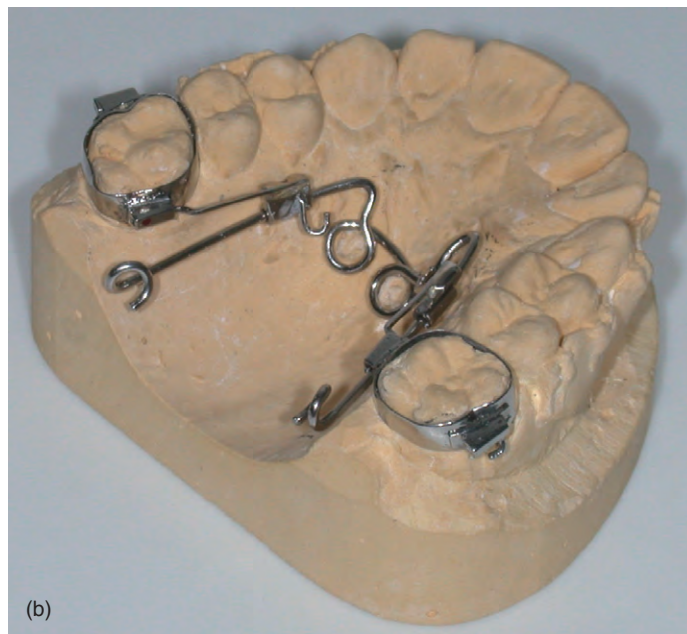


Figure 7.6 (a) A 'pushcoil' distaliser with a 0.019×0.025 steel archwire frame inserted in the transverse cross-slots of the parallel para-sagittal mini-implant heads. The distaliser frame is contoured over the palate, has Gurin locks anteriorly, pushcoil springs and its distal ends pass through soldered headgear tubes. (b) A 'traction' distaliser with a 1.0mm steel wire frame formed into loops around the para-sagittal mini-implant heads and posterior circular hooks. Traction will be applied from these posterior hooks to hooks on the free-sliding (headgear) tube on the distaliser frame, creating a distaliser force on the adjacent first molar. (c) A working model with para-sagittal Infinitas mini-implant analogues and first molar bands in situ. Headgear tubes have been soldered to the latter. Parallelism of the mini-implants can be checked by viewing the orientation of the mini-implant abutments. (d) The cross-slots of the analogues have been aligned and a 0.019×0.025 steel wire is bent to conform to the analogue positions. This wire is then used during clinical alignment of the mini-implant heads. (e) A 'double barrelled' insertion stent, where the medial aspects of the guidance cylinders have been trimmed to enable their close approximation.

lock (which may not fit on wires greater than 0.5mm diameter) or composite stops added to the distaliser frame.

Traction distaliser

The avoidance of pushcoil means that this design may use a relatively large diameter distaliser wire, e.g. 1.0mm stainless steel, which is rigid and hence unlikely to flex and indirectly lose anchorage. This diameter of wire also fits more precisely inside headgear tubes, providing rotational control over the attached molars. The active component is a traction

auxiliary such as a NiTi coil spring, which provides a sufficient range of activation (without requiring reactivation).

This distaliser design may involve either direct connection on the mini-implants or close encirclement of their heads by anterior loops formed in the wire frame (Fig. 7.6b). The small void between the loops and mini-implants is filled with orthodontic composite or acrylic resin. Therefore, there is no need to fully align the mini-implant heads with one another at insertion, although peri-implant hygiene is slightly restricted.

Clinical steps for a mid-palatal distaliser

Pre-insertion

1. Place separators adjacent to the maxillary first or second molars for one week.
2. Take an alginate impression with sized molar bands in situ, then replace the separators.

Laboratory distaliser fabrication

3. Cast a working model including the molar bands.
4. Mark two para-sagittal insertion points: 6–9mm distal to incisive foramen and 3–6mm lateral to midline (suture). This is typically in the same transverse plane as the premolars.
5. Drill the first pilot hole in the model, angled at 20–30° inclination towards the incisors.
6. Insert the first analogue and then fit an abutment onto this analogue.
7. Drill a second hole and insert the second analogue in a mirror image position on the other side and at the same inclination as the first one (Fig. 7.6c). This parallel alignment is assisted by using the first abutment as a reference plane for the second drilling direction.
8. If it is planned that the distaliser will directly engage the mini-implant cross-slots then align the analogues to make these parallel. It is also worth forming an alignment wire from a piece of 0.019×0.025 steel archwire to fit into the analogue and mini-implant heads (Fig. 7.6d). This is very useful at the clinical stage, to help with paralleling the cross-slots during final seating of the mini-implants (rather than repeatedly taking the whole distaliser in and out).
9. Solder headgear tubes onto the palatal aspect of the molar bands for the pushcoil version (Fig. 7.6a), or to a wire extending anteriorly from the molar bands for the traction version (Fig. 7.6b).

10. Form the distaliser frame by bending a 1.0mm round wire with anterior loops to encircle the mini-implant positions, or a 0.019 × 0.025 steel archwire to fit through both the analogue slots and headgear tubes. Ideally, make the latter (narrow) wire frame more rigid by adding wire struts or metal tubing to the corner sections.
11. Traction version: solder a hook to the headgear tube then slide it (and the molar band assembly) onto the main distaliser wire.
Pushcoil version: add a Gurin lock(s) and passive open coil spring(s) to the distaliser frame.
12. Leave an adequate length of the distaliser frame distal to the molars to provide sufficient distalisation range then coil the terminal ends (to avoid tongue irritation).
13. Make a stent (on the same dental model) according to the normal fabrication process, except that the median side of the guidance cylinders may need to be trimmed to enable both cylinders to seat on the model simultaneously (Fig. 7.6e).

Mini-implant selection

14. A short, wide diameter mini-implant is indicated since the palate is an edentulous site with limited depth, e.g. for Infinitas use the 2mm diameter, 6mm length, long neck version.

Insertion

15. Superficial anaesthesia of the insertion sites either directly or using nasopalatine and greater palatine blocks.
16. Fit the guidance stent.
17. Remove a punch of mucosal tissue from the insertion sites.
18. Perforate the cortical plate using a cortical punch.
19. Insert two mini-implants using a contra-angle handpiece.
20. If parallel cross-slots are required then use the alignment wire (Fig. 7.6d) to check that these are level and parallel with one another on final seating (by small repeated clockwise rotations using the handpiece or a mini-screwdriver).
21. Cement the distaliser bands onto the molars and simultaneously seat the wire frame into or around the mini-implant heads. The active components should be passive at this point. The wire frame is secured by adding composite resin or ligature wires to the mini-implant heads.
22. Activate the distaliser either by: compressing the coil spring(s) through advancement of the Gurin lock(s), or adding crimpable stops onto the distaliser frame; or by adding traction in the form of elastomeric chain.

Post-insertion

23. Check and if necessary re-activate the active components every six to eight weeks, i.e. switch to NiTi closing springs for prolonged traction activity, or re-compress the NiTi coil spring(s).
24. After the distalisation phase use the distaliser to anchor the molar positions, as the premolar and anterior teeth are retracted.
25. Once anchorage is no longer required, trim the composite resin to separate the mini-implants and the distaliser frame, then remove the latter.
26. Explant the mini-implants using a contra-angle handpiece with counter-clockwise rotations.

CASE EXAMPLES**1. Mid-palatal pushcoil distaliser (Fig. 7.7)**

- A 13 year old boy with a Class II division 1 malocclusion on a mild skeletal II base (Figs 7.7a, b). A conventional distaliser had previously been used, but the Class II corrections relapsed after the appliance broke. Subsequently, the OJ and OB remained increased, and the canine relationships were $\frac{3}{4}$ and $\frac{1}{4}$ unit Class II on the right and left sides respectively.
- Upper fixed appliance alignment and levelling had been undertaken, with the exception of the partially erupted upper second premolars.
- 2.0mm diameter, 6mm length, long neck mini-implants were inserted para-sagittally, in line with the first premolars (Fig. 7.7c) and a pushcoil distaliser fitted.
- Asymmetrical distalisation was achieved with more than half a unit of this movement occurring on the right side (Figs 7.7d–f). The anterior teeth were retracted towards the premolars using indirect anchorage of the latter teeth.
- The mini-implants were explanted once the anchorage was no longer required (Fig. 7.7g).
- Treatment was completed without the need for substantial amounts of intermaxillary traction (Figs 7.7h–j).

2. Mid-palatal pushcoil traction distaliser (Fig. 7.8)

- A 16 year old male presented with a Class III malocclusion on a moderate skeletal III base, and impacted upper second molars. His treatment plan involved fixed appliance alignment, with partial decompensation, and a maxillary advancement osteotomy. The impacted molars were removed during surgery, in order to avoid a second surgical procedure, and the immediate post-operative occlusion was planned to be Class II (Figs 7.8a–c). This would then be corrected by maxillary molar distalisation.
- Two palatal mini-implants (Infinitas 2.0mm diameter, 6mm length, long neck versions) and a 'traction' distaliser were inserted two months after surgery (Fig. 7.8d). This was fabricated to correct a $\frac{1}{4}$ and $\frac{1}{2}$ unit Class II canine relationship on the right and left sides, respectively, using NiTi coil spring traction. The first molars were banded and the distaliser loops were secured around the mini-implant heads with composite resin.
- Class I canine relationships were achieved after four months (Figs 7.8e, f). The molar relationships had been over-corrected and intrusion of the upper first molars was noted. The right limb of the distaliser was sectioned to allow settling, whilst the left side was retained for active anchorage during conventional retraction of the upper labial segment (Fig. 7.8g).
- The distaliser was removed and the mini-implants explanted (after six months in situ) when it was obvious that some anchorage loss could be afforded during final space closure and finishing stages (Figs 7.8h–k).



Figure 7.7 (a–c) The start of maxillary molar distalisation using a ‘pushcoil’ distaliser, and with a fixed appliance already in situ. A reserve of several millimetres of distaliser frame wire extends distal to the molar tubes bilaterally. ((c) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (d–f) End of the distaliser phase, once Class III molar and Class I canine relationships have been achieved. ((f) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (g) Explantation of the mini-implants at the repositioning appointment. (h–j) Views taken 18 months after debond.



Figure 7.7 *Continued*



Figure 7.8 (a–d) Molar distalisation beginning after a maxillary advancement osteotomy (to an over-corrected Class II incisor relationship) and surgical removal of impacted upper second molars. (e, f) Molar intrusion occurred during distalisation with the ‘traction’ distaliser. At the same time intra-arch elastomerics were used to retract the incisor teeth and move the centreline to the left. (g) The right side of the distaliser frame was cut off and unilateral traction continued on the left side. (h–k) End of the distaliser phase, with Class I canines and incisors, and a corrected maxillary centreline. The distaliser components and mini-implants were removed, and upper molars bonded to facilitate vertical settling.

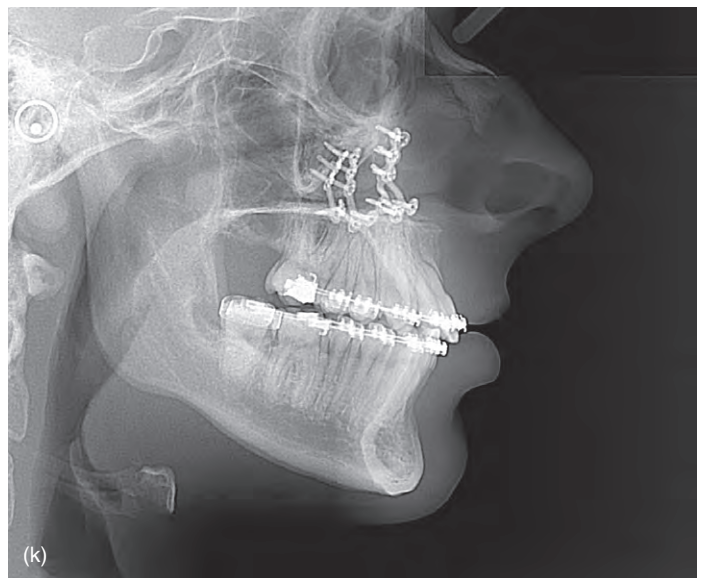


Figure 7.8 *Continued*

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Molar Protraction

Conventional anchorage provides very limited options for anterior anchorage reinforcement during molar protraction, especially in the mandibular arch. It typically involves using the anterior teeth as the anchorage unit, but this is limited by these teeth's relatively low combined root surface areas. Consequently, many orthodontists are historically reticent to attempt closure of large posterior spaces, especially if alveolar necking is present. Fortunately, mini-implant anchorage now means that many more such patients can be treated orthodontically, although one still needs to be realistic in terms of the difficulties posed by alveolar deficiencies. Therefore it is crucial to assess the feasibility of space closure in terms of both the anchorage requirements and the edentulous site anatomy. In lieu of surgical alveolar ridge augmentation, substantial reductions in alveolar height and width may severely limit mesial movement of the posterior teeth, especially in hypodontia cases (where the alveolus is hypoplastic) or long-standing edentulous sites (where it has atrophied). Furthermore, the molar which is adjacent to the distal aspect of such an alveolar problem is much more prone to mesial tipping problems, although there are now biomechanical solutions for this problem whereby bodily movement can be promoted.

Assess the feasibility of space closure in terms of both the anchorage requirements and the edentulous site anatomy.

Mini-implant sites in the mandibular arch are limited to the buccal aspect of the alveolus, whilst maxillary protraction can utilise options of either buccal and palatal alveolar (direct) or mid-palate (indirect) anchorage.

Clinical objective

- To prevent distal movement of the anterior teeth during molar protraction for closure of a posterior space (e.g. a second deciduous molar or permanent molar site).

Treatment options

- Buccal alveolar mini-implant anchorage (direct or indirect) in either arch.
- Palatal alveolar mini-implant (direct) anchorage.
- Indirect anchorage of upper incisors using mid-palate mini-implant(s).
- Mid-palate mini-implant protraction appliance (reverse distalizer).
- Indirect anchorage using buccal mini-implants for intermaxillary traction.
- Conventional anchorage, e.g. protraction headgear or intermaxillary elastics.
- Alteration of the skeletal base by orthognathic surgical or orthopaedic appliance treatments, in order to offset anterior anchorage loss (incisor retraction).

Key treatment planning considerations

- The molar, incisor and centreline relationships.
- The quantity and quality of the alveolar ridge in the edentulous space. If a tooth is still present here,

then is it ankylosed, or did infection or other pathology cause bone loss?

- The depth and shape of the palatal vault, since a high arched palate makes it difficult to insert mini-implants in the mid-palate.
- The interproximal bone volume at the proposed mini-implant (alveolar) site, in terms of both the mesio-distal space (root divergence) and bucco-lingual alveolar depth. Limitations in both dimensions mean that an oblique angle of mini-implant insertion and possibly a shorter body length are preferable. Alternatively, as suggested by experts such as German orthodontist Dr. Björn Ludwig, a long mini-implant may be inserted perpendicular to the surface with the aim of bicortical engagement. This option requires additional lingual anaesthesia and then composite resin coverage of the mini-implant tip, if it projects beyond the lingual tissues, risking tongue irritation. In addition to the benefit of bicortical anchorage support,¹ this lingual projection may also be used to provide supplementary traction to the lingual side of the molar, hence reducing the risk of molar rotation during mesialisation.
- The amount of mesialisation required and whether this differs on each side of the arch.

Biomechanical principles

- Hypodontia cases may have limited alveolar bone width/height at the mini-implant insertion site. This especially affects insertions adjacent to the canine eminence, which may be under-developed if the canine erupted in an ectopic position.
- Prepare the fixed appliance ready for mini-implant insertion (by divergence of adjacent roots) and the simultaneous initiation of space closure by progressing to a rigid working archwire, e.g. a 0.019 × 0.025 stainless steel one.
- If a lengthy period of initial alignment is required, then consider delaying any extractions, especially of ankylosed deciduous molars, until the arch is ready for the immediate start of space closure. Otherwise, alveolar resorption may occur at an already compromised site and limit space closure.
- Forces applied at the coronal level will tip molars mesially during protraction, especially if there is a vertical alveolar deficiency on the mesial aspect of the molar. This also tends to be worse if a second molar is not available or attached to help control the first molar alignment.
- Mesial tipping of molar teeth causes archwire binding and consequently frictional problems

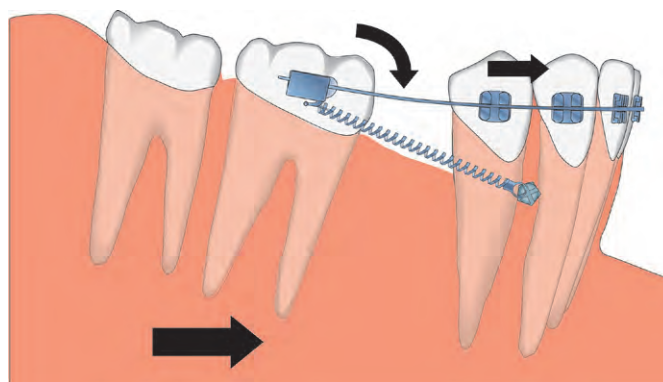


Figure 8.1 Diagram of the side-effects of oblique traction from an anterior mini-implant to the first molar hook and a reduction in the adjacent alveolar height: molar tipping causes archwire binding and advancement, resulting in incisor protraction and intrusion.

(Fig. 8.1), then possibly protraction (mesial shunting) of the entire dental arch and incisor intrusion. This manifests as a reduction in overjet and overbite (Fig. 8.2).

- The use of a posterior powerarm, to apply traction at the molar furcation level, assists bodily molar movement and unidirectional space closure. Powerarms may be free-sliding on the archwire (Fig. 8.3) although they provide better bodily control when attached directly to a molar crown. The latter approach involves placement of a double tube attachment on at least one molar per dental quadrant, then fabrication of a steel powerarm from a piece of rigid archwire, e.g. 0.021 × 0.025 size (Figs 8.4 and 8.5).

Consider delaying any extractions, especially of ankylosed deciduous molars, until the arch is ready for the immediate start of space closure.

Mid-treatment problems and solutions

- Ideally only apply traction to a powerarm in order to optimise bodily molar movement.
- Bond or band the second molar, in each relevant quadrant, since this helps to control mesial tipping of the first molar and enables direct closure of any inter-molar spaces.



Figure 8.2 An adolescent girl with a Class II division 1 malocclusion and absent second premolars. (a) An oblique vector of elastomeric traction was applied from the mandibular mini-implant, inserted mesial to the first premolar, directly to the first molar hook. This resulted in (b) a reduction in the overjet and overbite as the lower incisors proclined and intruded. Elastomeric traction was then added between the molar and archwire hooks, to prevent mesial movement of the archwire. (c) Control of the incisor relationship had been achieved after eight weeks of combined traction and (d) continued during the complete phase of molar protraction.



Figure 8.3 An adult Class III patient who required protraction of the lower right second and third molars prior to a mandibular osteotomy. Chronic infection had resulted in severe alveolar bone loss in the first molar area. (a, b) Two mini-implants were inserted, because of the anticipated difficulties with space closure, and elastomeric traction connected to a sliding powerarm (on the archwire distal to the second molar tube) and third molar hook. (c, d) Space closure was achieved with bodily molar mesialisation.

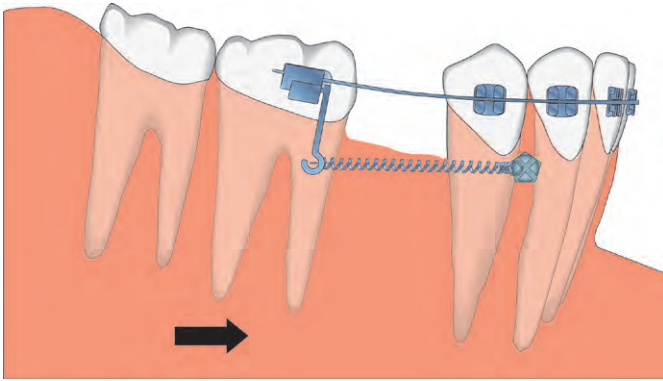


Figure 8.4 Diagram of bodily molar protraction utilising a powerarm connected to the molar tube to achieve a horizontal vector of traction.

- A shallow posterior buccal sulcus depth may prevent initial placement of a powerarm, especially on the terminal molar, but this can be added once sufficient mesial movement of the molar moves it into an area with more sulcus depth.
- If there are signs of unfavourable incisor intrusion then add a bite-closing curve to the archwire.
- If incisor advancement and proclination occur, as a result of archwire binding, then consider adding supplementary traction from the molars to the anterior teeth or archwire hooks (Figs 8.2b, c).



Figure 8.5 An adult patient with a double molar tube bonded on the upper left second molar. A 0.019 × 0.025 steel wire has been used to fabricate a powerarm which engages the auxiliary molar tube and mirrors the vertical level of the mini-implant.

The use of a posterior powerarm, to apply traction at the molar furcation level, assists bodily molar movement and unidirectional space closure.

Clinical steps for molar protraction using alveolar site anchorage

Pre-insertion

1. Determine the optimum mini-implant insertion site(s), e.g. mesial or distal to the first premolar, depending on whether the second premolar is present. It is preferable to avoid insertions mesial to the canines because of limited interproximal space here and the risk of the traction auxiliary traumatising the soft tissue over the canine eminence (the 'corner' of the arch).
2. Increase the available interproximal space by bonding the adjacent teeth at altered attachment tips, e.g. for an insertion distal to the canine add mesial tip to the canine bracket, causing the root to move mesially (away from the insertion site) during initial alignment.
3. Bond a double tube on either the first or second molar(s).
4. Align and level the arch ready for insertion of a 0.019 × 0.025 stainless steel archwire.
5. Arrange the planned extraction of retained posterior teeth, e.g. ankylosed deciduous molars, with a view to commencing space closure immediately and before alveolar resorption occurs. It is crucial to request that the buccal and lingual sides of the extraction socket should not be compressed (as is customary following extractions), so that the alveolar width is not actively restricted.

Request that the buccal and lingual sides of the extraction socket should not be compressed (as is customary following extractions), so that the alveolar width is not actively restricted.

Mini-implant selection

6. Maxilla: use a long mini-implant especially if the alveolus appears to be diminutive at the insertion site, e.g. a 1.5mm diameter, 9mm length, short neck Infinitas version.
7. Mandible: the length selection depends on the anticipated cortical depth and density, i.e. select a long (9mm) body length in an adolescent patient or if angulated insertion is indicated (because of limited attached gingival height). A short (e.g. 6mm Infinitas version) is usually sufficient in adults where there is sufficient attached gingival depth and cortical density to enable the insertion to be vertically perpendicular to the bone surface.

Insertion

8. Superficial anaesthesia of the insertion site.
9. Identify the ideal buccal alveolar insertion point, through attached gingiva (which precludes the need for a soft tissue punch step), and either mesial or distal to the first premolar.
10. Determine the angles of insertion. All mini-implants are inserted into the interproximal space and perpendicular to the surface in the horizontal plane. In vertical terms, maxillary mini-implants may be inserted either perpendicular to the surface or at an oblique angle (up to 30° in an apical direction). Mandibular insertions are generally perpendicular to the vertical plane unless a lack of attached gingival height necessitates an oblique of insertion.
11. Manual screwdriver insertion is feasible where physical access (e.g. stretching of the cheek) is sufficient for correct screwdriver orientation. A cortical bone punch is recommended as the first step for mandibular sites in adult patients.
12. Take an intra-oral radiograph if close root proximity is suspected.
13. Complete insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible.

Post-insertion

14. Add a powerarm, e.g. formed from 0.021 × 0.025 rectangular steel wire, through the molar auxiliary tube, with an appropriate length to create a horizontal line of traction (parallel to the occlusal plane).
15. Immediately load the mini-implant with a low force level (approximately 50g) for the first five to six weeks, e.g. using a lightly stretched powerchain. Subsequently apply traction using a NiTi coil spring or elastomeric auxiliary.
16. Add supplementary (conventional) traction and/or a bite closing archwire curve if the incisor relationship changes unfavourably in terms of incisor proclination and intrusion, respectively. The simplest form of additional traction is from a posted archwire hook to the molar (Figs 8.2 b,c). If there are signs that molar rotation is causing archwire binding then add traction to the lingual side of the molar (e.g. to a bondable cleat) to encourage true mesial translation of the molar.
17. Discontinue the traction and consider explanting the mini-implant once sufficient space closure has occurred and the protracted teeth are upright.

CASE EXAMPLES**1. Direct protraction: example one (Fig. 8.6)**

- A 15 year old male with a Class II division 2 malocclusion, absent lower right first premolar and a severe shift of the lower centreline to the right side (Fig. 8.6a). The treatment plan involved extraction of the upper right first premolar and closure of both right premolar spaces.
- Most of the lower right premolar space re-opened during alignment, levelling and centreline correction such that anterior anchorage was required to prevent relapse of these changes during subsequent mesialisation of the second premolar and molars.
- Direct traction was applied from a 1.5mm diameter, 9mm length, short neck mini-implant to a conventional molar attachment hook (Fig. 8.6b). The insertion site was mesial to the lower right canine since a more posterior position would have interfered with space closure. The lower right first molar did not exhibit excessive mesial tipping because the second premolar provided a buffering effect between the molar and edentulous space. The elastomeric traction modules rested on the canine crown rather than catching on soft tissues.
- After closure of the lower space, the mini-implant was used for indirect anchorage of Class III elastic traction (Fig. 8.6c). This assisted upper arch space closure and upper centreline correction, whilst avoiding any transverse (and vertical) side-effects on the corrected lower arch (Fig. 8.6d).

2. Direct protraction: example two (Fig. 8.7)

- An adult hypodontia patient with a Class II division 2 malocclusion and absent second premolars (Figs 8.7a–g). She required closure of four second deciduous molar spaces by protraction of all three molars in each quadrant by up to 10mm, especially to dis-impact the lower third molars (Figs 8.7e, g). Orthodontics was greatly complicated by ankylosis of the deciduous molars (4mm infra-occlusion), severe alveolar bone deficiencies and the desire to avoid incisor retraction.
- The lower arch was aligned prior to simultaneous surgical removal of the deciduous molars and insertion of mini-implants distal to the mandibular canines. Traction was applied to powerarms on the lower archwire and upper sectional fixed appliances were also bonded (Fig. 8.7h).
- Lower archwire binding (molar tipping) caused advancement of the lower incisors (manifesting as overjet and overbite reductions), so the traction mechanics were changed such that the mini-implants indirectly anchored traction from the first premolars (Fig. 8.7i). At the same time, maxillary mini-implants were inserted distal to the canines and traction was applied directly to the first molar attachment, but at an excessively oblique vector. This resulted in rotation of the maxillary buccal segment and hence intrusion of the canines, necessitating removal of all mini-implants and the application of conventional traction in the lower arch (Fig. 8.7j).
- Substantial mesialisation of the mandibular first and second molars was achieved following the insertion of a second pair of mini-implants, but mesial tipping of the mandibular molars again caused archwire binding effects (Fig. 8.7k). The lower third molars had displayed a large amount of passive mesial movement (Fig. 8.7l) before direct traction was applied to double tubes bonded on their crowns.
- Final maxillary molar protraction was assisted by anchorage of the incisors using a palatal mini-implant and inter-connecting 0.019 × 0.025 steel auxiliary wire (Figs 8.7m, n).
- Complete space closure and alignment of the third molars was achieved. The iatrogenic AOB was corrected, with the assistance of 'bite closing' curves in the archwires. Incomplete settling of the buccal occlusion was accepted at debond because of tooth size discrepancies and in order to favour overbite consolidation (Figs 8.7o–s).
- Cephalometric superimposition (Fig. 8.7t) showed substantial molar protraction, upper incisor bodily retraction and modest lower incisor retroclination, but no significant change in the soft tissue profile and vertical parameters.

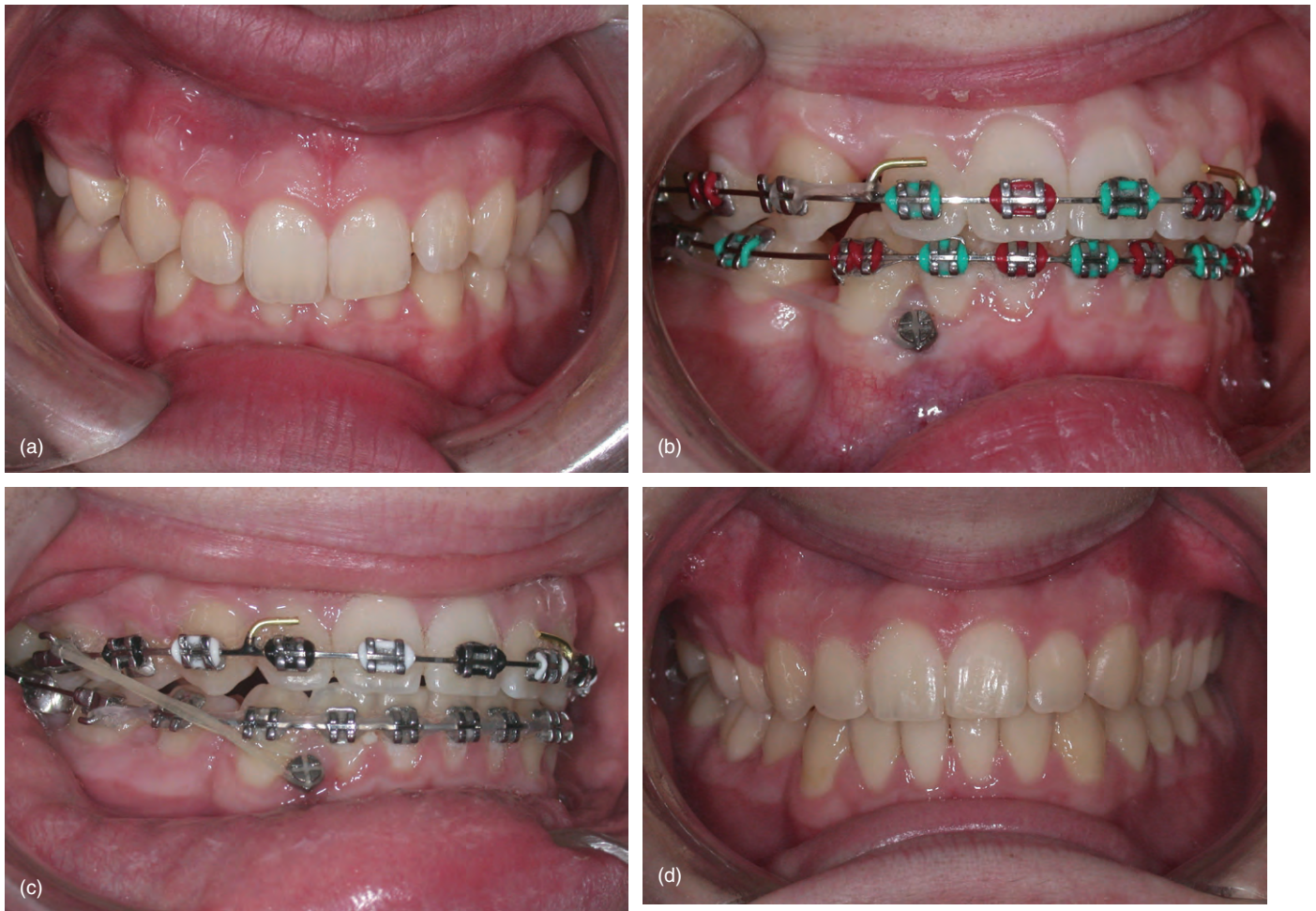


Figure 8.6 (a) Pre-treatment view showing the Class II division 2 malocclusion, absent lower right first premolar and associated significant lower centreline shift to the right side. (b) The upper right first premolar had been extracted and fixed appliance alignment performed. The lower centreline was corrected by opening the premolar space during this phase. Traction was then applied to the first molar from a mini-implant inserted distal to the lower right canine. (c) Lower arch space closure was achieved by molar protraction. The mini-implant was then used to provide Class III traction for maxillary molar space closure, without affecting the lower centreline. ((b and c) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (d) Debond view after full space closure and where some over-correction of the lower centreline was retained.



Figure 8.7 (a–g) Pre-treatment views showing this Class II division 2 malocclusion, absent second premolars, ankylosed second deciduous molars with severe alveolar height deficiencies, and impacted mandibular third molars. (h) Mandibular mini-implants were inserted distal to the canines, after surgical removal of the deciduous molars, and traction was applied to a sliding powerarm distal to the first molar tubes. (i) The traction was changed to an indirect form using a ligature wire to anchor the first premolar. Maxillary mini-implants were inserted at this time, with oblique traction to the first molar. (j) Two further problems manifested at this stage of treatment: gingival hyperplasia required removal of the mandibular mini-implants and poor biomechanical control resulted in rollercoaster bowing of the maxillary buccal dentition. (k, l) Two replacement mandibular mini-implants were inserted for traction to the second molars, resulting in substantial molar protraction and indirect mesial drifting of the impacted third molars. (m, n) Further maxillary molar protraction utilised indirect anchorage from a mid-palatal mini-implant. Bilateral intra-arch traction avoided rotational effects on the single implant. (o–s) Treatment was completed after protraction of all twelve molar teeth, complete space closure and explantation of the three mini-implants. (t) Cephalometric superimposition showed substantial molar protraction, upper incisor bodily retraction and modest lower incisor retroclination, but no significant change in the soft tissue profile and vertical parameters.

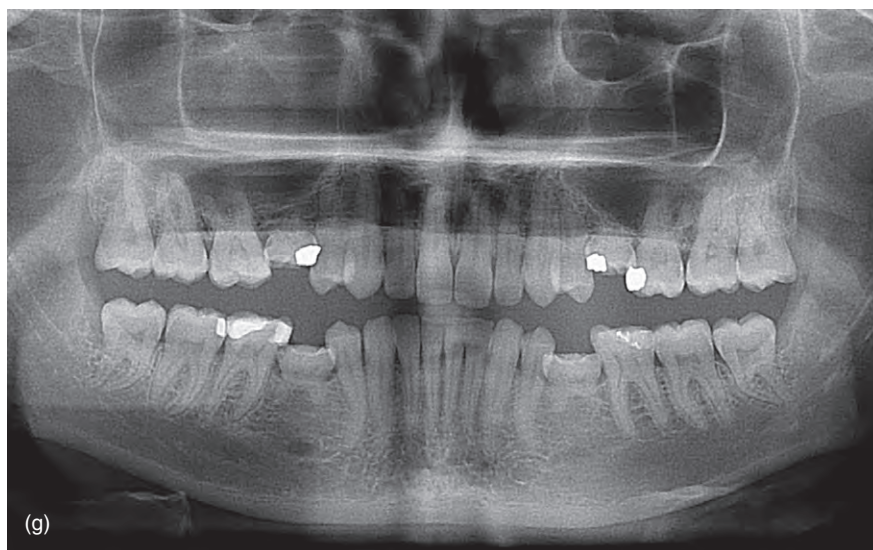
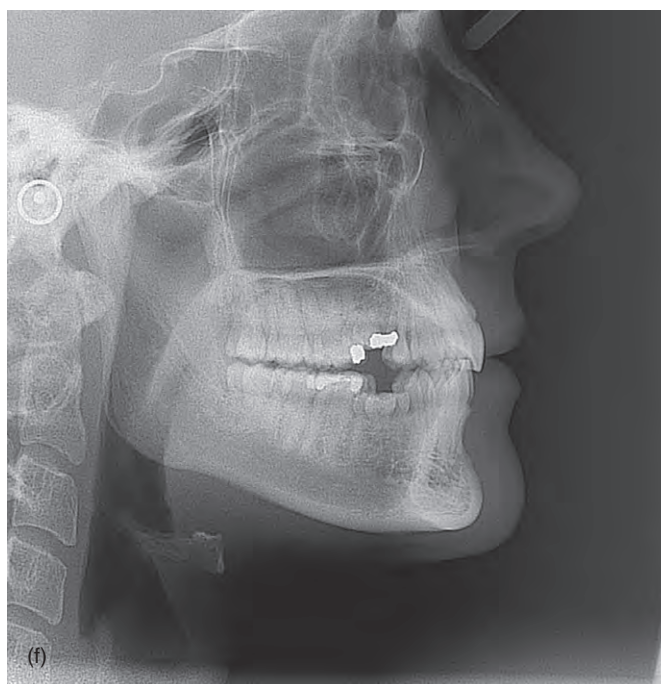


Figure 8.7 *Continued*



Figure 8.7 *Continued*

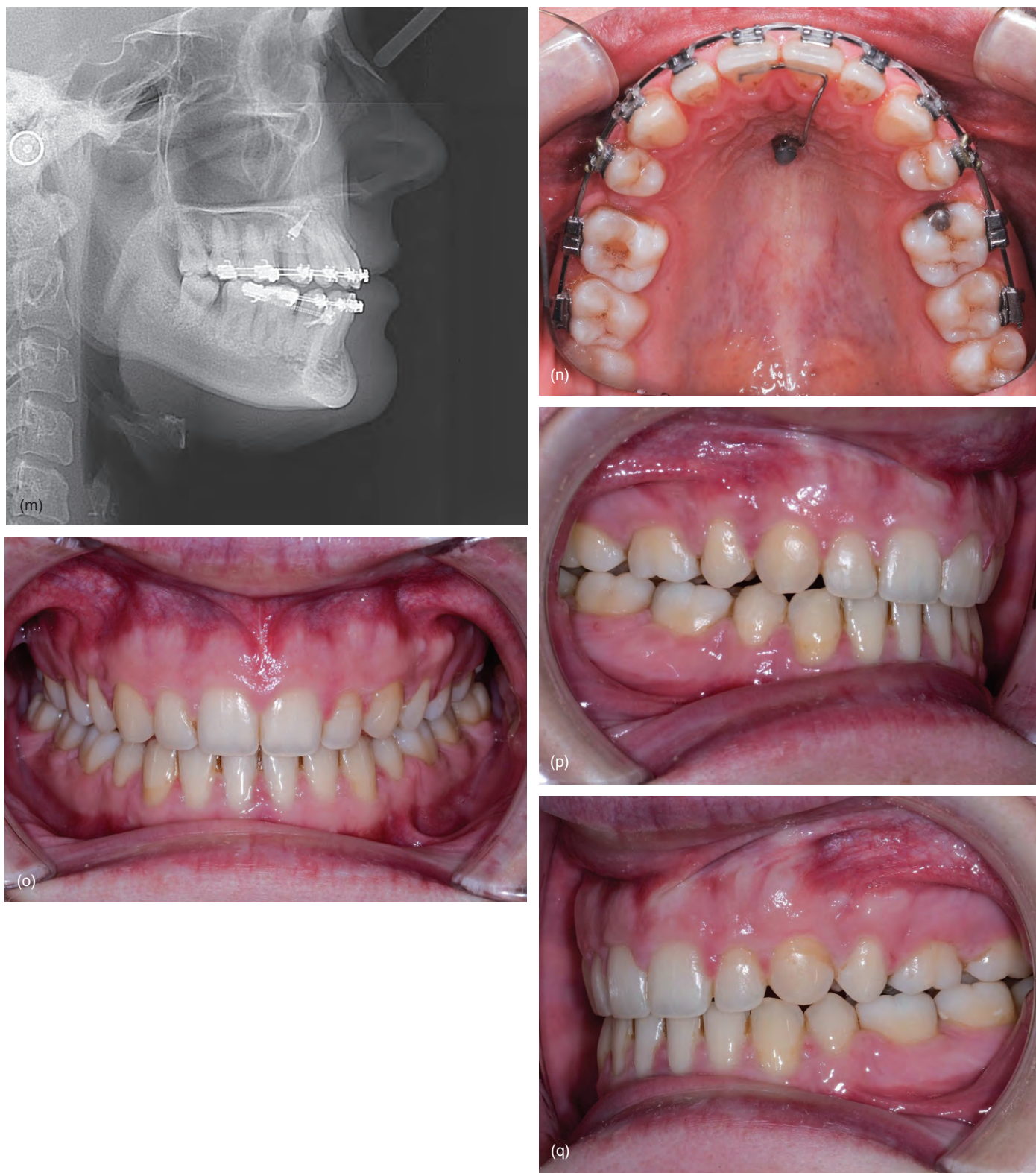
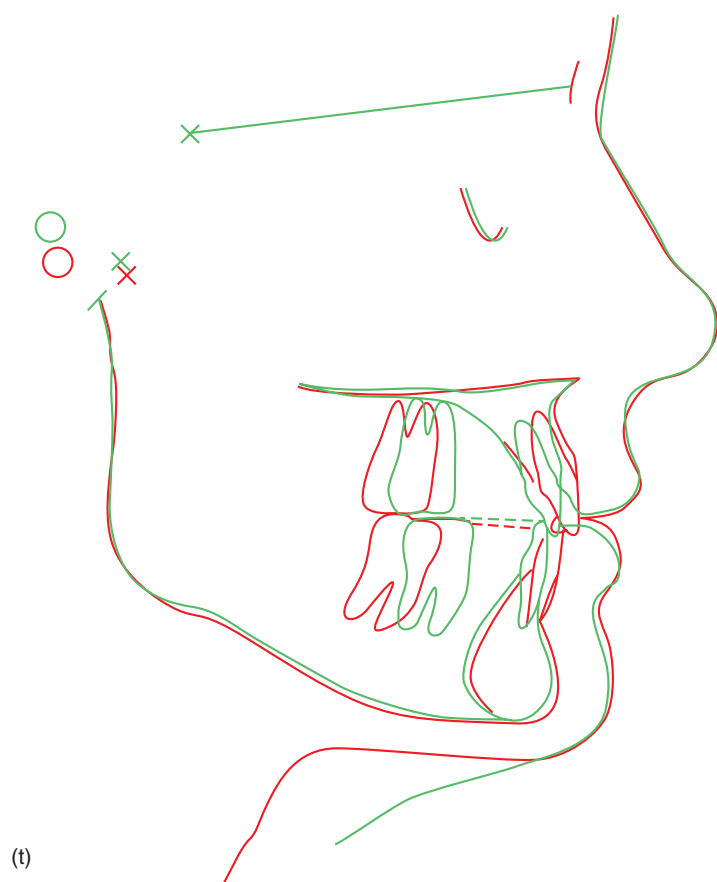


Figure 8.7 *Continued*



SKELETAL			SOFT TISSUES		
SNA	°	−0.5	Lip Sep	mm	2.0
SNB	°	−1.0	Exp UI	mm	1.0
ANB	°	0.0	LS-E	mm	0.0
SN/MxP	°	1.5	LI-E	mm	0.5
MxP/MnP	°	−2.0	NLA	°	6.5
LAFH	mm	−1.0	LLA	°	−9.5
UAFH	mm	0.5	Holdaway	°	0.0
LAFH/TAFH %		−0.5			
LPFH	mm	1.0	NOSE PROMINENCE		
UPFH	mm	−0.5	Nose tip	mm	−1.0
PFH	mm	0.5	Nose angle	°	−0.5
Wits	mm	3.0			
TEETH			CHIN PROMINENCE		
Overjet	mm	0.0	Chin tip	mm	−1.0
Overbite	mm	−0.5	B-NPo	mm	0.5
UI/MxP	°	1.5	LADH	mm	−2.0
LI/MnP	°	−4.0			
IIangle	°	4.0			
LI-APo	mm	−2.0			
LI-NPo	mm	−2.0			

Figure 8.7 *Continued*

Clinical steps for mid-palate (indirect) anchorage*Pre-insertion*

1. Align and level the maxillary arch ready for insertion of a passive 0.019 × 0.025 steel archwire. It may be ideal to undertake finishing adjustments, in terms of repositioning the central incisor brackets, at this stage since this then enables the indirect anchorage to be applied to these teeth until the completion of treatment (or even into retention).
2. Evaluate the anterior palatal depth on a lateral cephalogram or CBCT.

Mini-implant selection

3. If bilateral traction is required then a single mini-implant may provide sufficient anchorage to prevent palatal movement of the incisor bloc (Fig. 8.7n). However, if the space closure and hence traction is unilateral, then a single mini-implant may be affected by counter-clockwise rotational moments, resulting in anchorage loss and a centreline shift (Fig. 8.8a). The auxiliary palatal wire may also be deflected in the direction of traction. The addition of a second mini-implant, either in the same transverse plane or in series, will mitigate this rotational side-effect (Fig. 8.8b).
4. Choose a short length mini-implant, given the limited palatal bone depth, e.g. for Infinitas use a 1.5 or 2.0mm diameter, 6mm body length, long neck version.

Insertion

5. Superficial anaesthesia of the insertion site.
6. The insertion site should be at the antero-posterior level of the premolars, to provide adequate bone depth whilst avoiding close proximity to the nasopalatine canal.
7. The insertion angle should be 20–30° to the vertical plane, angled towards the anterior nasal spine, since this both directs the implant through the optimum bone depth and avoids the contra-angle handpiece from contacting the incisal edges at the final insertion stage.² A guidance stent may be useful in this respect.
8. Use a slow speed (e.g. 128:1 ratio) contra-angle handpiece insertion to overcome the restricted physical access.
9. Both soft tissue and cortical bone punch steps are recommended in the mid-palate area.
10. Complete insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible. However, if the patient has a limited depth of palatal bone then the patient may experience sensitivity on the nasal side which prevents full depth insertion.

Post-insertion

11. Bond a passive auxiliary wire (e.g. 0.019 × 0.025 steel) through the mini-implant head and onto the palatal surfaces of the central incisor crowns. This wire requires a pre-formed step to prevent slippage through the mini-implant head, and hence anchorage loss. It should also be contoured over the palate surface and form a rest on the incisors' palatal surfaces. These features are best achieved if this wire is pre-shaped using a recent plaster model (with the mini-implant position evident).
12. Immediately apply traction from the anterior (anchor) teeth to the molar(s). Use *light* (approximately 50g) traction for the first five to six weeks, e.g. using a lightly stretched powerchain, then apply full traction using a NiTi coil spring or elastomeric.
13. Remove the auxiliary wire +/- explant the mini-implant once the anchorage requirements have been met. This may entail air rotor sectioning of the mini-implant head to free the wire, but this is not problematic for mini-implant removal in the case of Infinitas since the screwdriver engages the (intact) neck section.

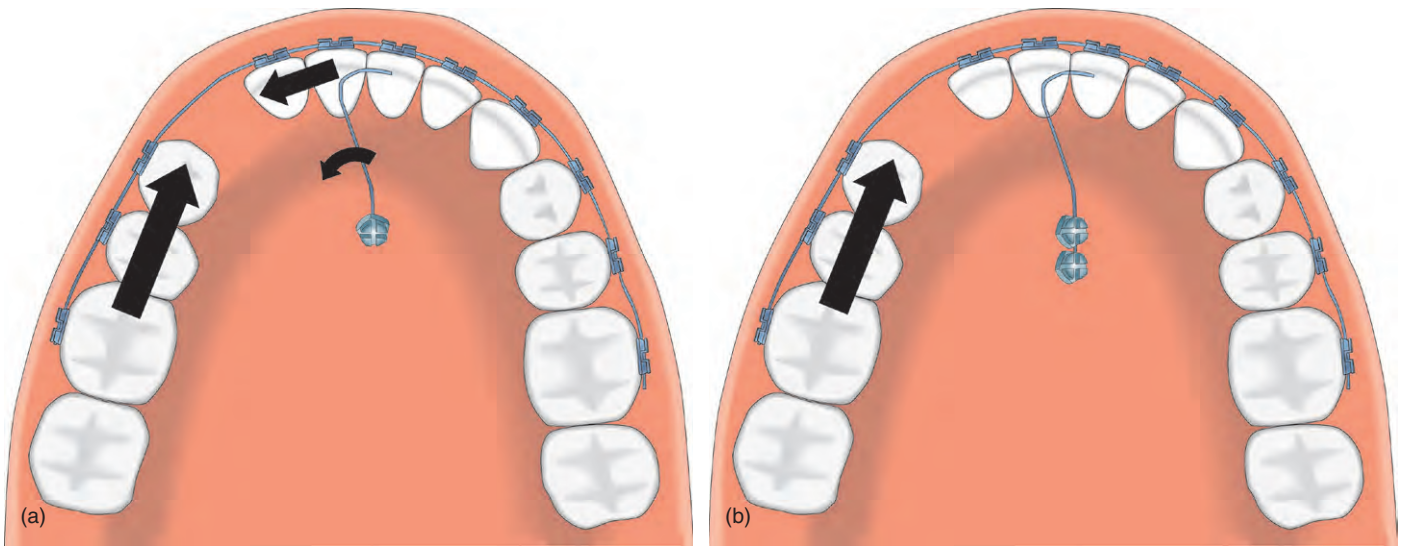


Figure 8.8 (a) Diagram of counter-clockwise (CCW) rotational side-effects occurring when right sided unilateral traction is applied to a mid-palatal (clockwise threaded) mini-implant. The CCW moment partially loosens the mini-implant resulting in unilateral movement of the incisor teeth. This anchorage loss may be exacerbated if the auxiliary wire flexes under traction. (b) The addition of a second palatal mini-implant stabilises the first against CCW rotational moments, reducing anchorage loss.

INDIRECT PALATAL ANCHORAGE EXAMPLE (Fig. 8.9)

- A 16 year old male with a Class I malocclusion and absent upper right canine tooth, requiring either prosthetic rehabilitation or space closure by protraction of the upper right buccal teeth. The latter was complicated by Class I occlusal interdigitation and alveolar bone hypoplasia in the canine area (Fig. 8.9a).
- A 1.5mm diameter, 6mm length, long neck Infinitas mini-implant was inserted in a para-sagittal site (Figs 8.9b, c) using a guidance stent. Final seating was undertaken by small incremental turns so that one of the mini-implant cross-slots was sagittally orientated. This enabled a pre-bent piece of 0.019×0.025 steel wire to fit passively into the cross-slot. This wire was secured at both ends by composite resin on the mini-implant head and the palatal surfaces of the upper central incisors.
- Elastomeric traction was applied from the incisor anchorage bloc to the right first molar hook (Fig. 8.9d) until space closure and a Class II right buccal occlusion was achieved (Figs 8.9e,f).

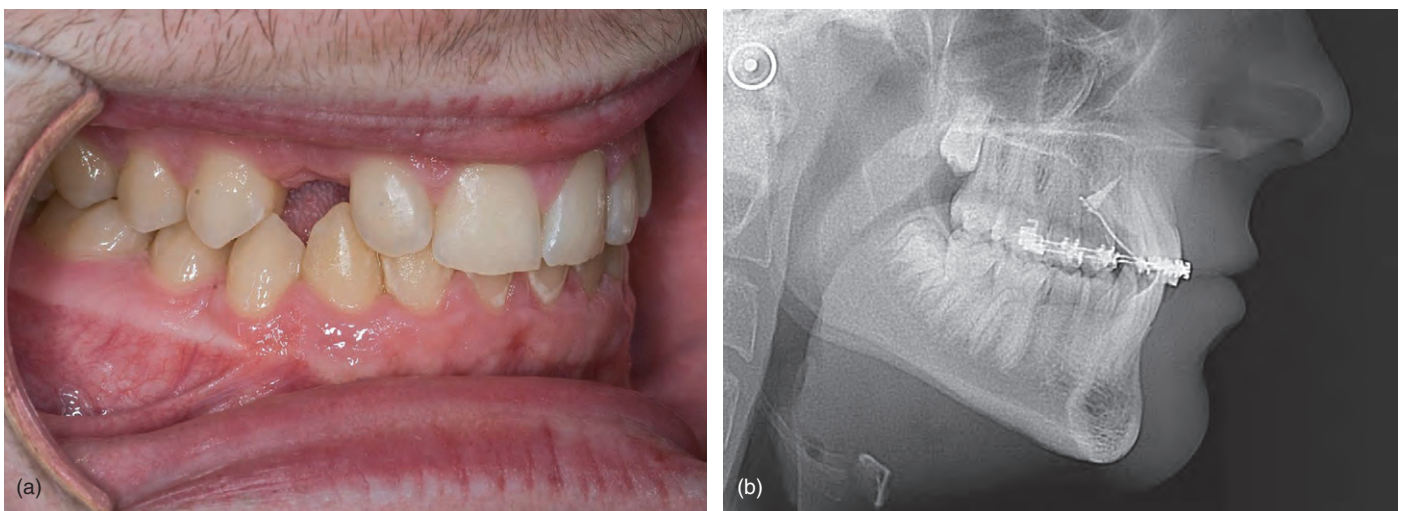


Figure 8.9 (a) Pre-treatment view showing this Class I malocclusion and absent upper right canine. (b, c) Indirect anchorage of the incisors, for unilateral molar protraction, using a palatal mini-implant and 0.019×0.025 steel auxiliary wire. Notably, direct traction from a buccal mini-implant was not deemed feasible because of the alveolar deficiency in the canine region. (d) Elastomeric traction applied from the lateral incisor to the first molar. Molar protraction was hindered by the buccal interdigitation, necessitating occlusal opening with molar props. (e, f) Canine space closure achieved by mesial movement of the buccal teeth into Class II positions.



Figure 8.9 *Continued*

References

1. Bretin BT, Grosland NM, Qian F, et al. Bicortical vs monocortical orthodontic skeletal anchorage. *Am J Orthod Dentofac Orthop* 2008; 134: 625–635.
2. Cousley R. Critical aspects in the use of orthodontic palatal implants. *Am J Orthod Dentofac Orthop* 2005; 127: 723–729.

Intrusion and Anterior Openbite Treatments

The ability to effectively intrude teeth (and avoid extrusion of anchor unit teeth) is one of the most revolutionary applications of mini-implant anchorage. For the first time in orthodontics it is realistic to intrude single or multiple anterior and posterior teeth, albeit with the caveat that the periodontium needs to be healthy in order to avoid an exacerbation of pocket depth. In the presence of normal periodontal tissues, the intrusion mechanism appears to involve alveolar remodelling (a reduction in alveolar height), rather than just submergence of the teeth within the alveolus. Kanzaki et al. (2007) suggested that this is 'conceptually equivalent to surgical impaction of alveolar bone by using a segmental osteotomy'.¹ Hence, only a limited reduction in clinical crown height occurs and normal probing depth is maintained. Furthermore, it appears that orthodontists' classical concern of apical root resorption (due to intrusive forces) is not a significant problem, even with relatively heavy forces.^{2,3}

In the presence of normal periodontal tissues, the intrusion mechanism appears to involve alveolar remodelling (a reduction in alveolar height).

SINGLE TOOTH AND ANTERIOR SEGMENT INTRUSION TREATMENTS

Clinical objectives

- Intrusion of an over-erupted tooth, or the entire group of upper or lower incisors to correct a deep

overbite, and perhaps also reduce excessive vertical incisal display.

Treatment options

- Conventional approaches such as reverse curve archwires or segmental arch mechanics.
- Maxillary impaction orthognathic surgery, especially in the presence of excessive gingival display and lip incompetence.
- Direct intrusive traction from labial/buccal mini-implants to the orthodontic brackets or archwire (Fig. 9.1). This may be supplemented in the maxillary arch by traction from a palatal alveolar mini-implant.
- Cantilever traction from mini-implants in 'remote' alveolar or palatal sites (if there is insufficient interproximal space adjacent to the target teeth).
- Indirect anchorage of a molar tooth whilst a utility intrusion arch or a cantilever wire is utilised from an auxiliary tube on the molar.

Relevant clinical details

- The incisor relationship and inclinations.
- Upper incisor vertical display (passive and smiling) in relation to the patient's age, i.e. is incisor intrusion beneficial in terms of reducing the incisal show or would this risk prematurely aging the patient?
- Presence of an occlusal cant/vertical facial asymmetry.
- The periodontal status since teeth should not be intruded in the presence of active periodontal disease (bleeding or pocketing).

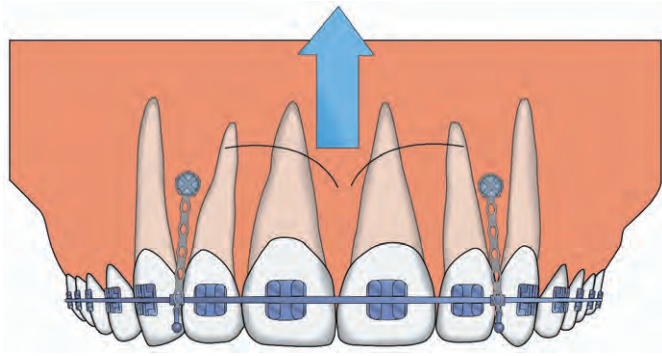


Figure 9.1 Diagram of incisor intrusion mechanics where vertical traction is applied from bilateral mini-implants, sited mesial to the canines, to the archwire or nearby brackets.

- The height of attached gingiva adjacent to the tooth/teeth to be intruded. If this is reduced then it will limit the intrusion range for direct traction (from an adjacent mini-implant), given that the intruding teeth will move towards the mini-implant. In this situation indirect anchorage of a posterior tooth and the use of an intrusive lever arm may be preferable.
- The root proximity of teeth adjacent to the planned insertion sites.

Biomechanical principles

- Buccal mini-implants may cause undesirable inclination/torque changes since traction applied to the labial crown surface tends to tip the crown labially. This is reduced by the use of a low profile mini-implant (where the traction is applied close to the gingival surface), insertion of the mini-implants distal to the canines, and/or the addition of archwire torque.
- If the incisors procline during intrusion then anterior spacing will develop. This is avoided by cinching back the ends of the archwire or applying traction for space closure.

Clinical tips and technicalities

- If there is a prominent labial frenum then either avoid midline mini-implant insertion or undertake a frenectomy to deter soft tissue interference or overgrowth (over the mini-implant head).
- Labial tipping of intruding single teeth may also be controlled by the use of a vacuum-formed baseplate to contact the coronal aspect of the crown and with a window cut to allow for apical movement of the attachment on the tooth.

Clinical steps*Pre-insertion*

1. Diverge the roots of teeth adjacent to the insertion site by bonding their brackets at altered tips, e.g. for insertion mesial to the canine root then add mesial tip to the lateral incisor bracket and distal tip to the canine one.
2. Level and align either the whole arch with a full fixed appliance, or only those teeth requiring intrusion with a sectional fixed appliance. This depends on the extent of the vertical discrepancy between the intruding and adjacent teeth, such that a large step favours segmental mechanics prior to full arch engagement.

Mini-implant selection

3. A narrow diameter mini-implant, e.g. 1.5mm short neck version, is appropriate for interproximal sites.
4. Select a mini-implant with a short neck to reduce the risk of the traction being more buccal (distant from the surface) than the crown surface and hence increasing the tooth's inclination.
5. If there is sufficient height of attached gingiva then the insertion should be perpendicular to the surface, in which case a relatively short body length (e.g. 6mm length Infinitas version) is appropriate and avoids the risk of lingual perforation. However, if a limited height of attached gingiva dictates that oblique insertion is required, then it may be more appropriate to select a longer body length (e.g. 9mm) mini-implant.

Insertion

6. Aim to insert the mini-implants close to or at the mucogingival junction in order to provide sufficient vertical range for continued tooth movements.
7. Superficial anaesthesia of the insertion sites.
8. Insert at least two mini-implants on the buccal side of the alveolus such that intrusive forces can be applied from both sides of the target tooth or group of teeth.
9. Take an intra-oral radiograph if close root proximity is clinically suspected.
10. Complete insertion to the point that the mini-implant neck is partially submerged and the head has a low emergence profile yet is fully accessible.

Post-insertion

11. Apply traction from the mini-implants to adjacent brackets or an archwire hook. Use approximately 50g (elastomeric chain) traction for the first four to six weeks, then increase the force to around 150g provided that a group of teeth are being loaded.
12. Monitor treatment progress by recording key features at the start of intrusion and at subsequent appointments: overjet, AOB/overbite, and buccal segment relationship.
13. Monitor the periodontal condition (probing depth) of the intruding teeth during treatment.
14. Consider over-correction of the intrusion effects to allow for possible relapse.
15. Keep the mini-implants in situ until it is clear that further anchorage is not required.
16. Consider an intensive initial retention regimen, e.g. three months full-time wear of full-coverage plastic retainers. This should prevent early vertical relapse of intruded teeth (but not of any extruded teeth).

CASE EXAMPLES**1. Single tooth intrusion case (Fig. 9.2)**

- A 45 year old female with a Class II division 1 malocclusion (Fig. 9.2a) complicated by mandibular retrognathia, a very low MMPA and a compromised dentition (unsuitable for comprehensive orthodontics). A mandibular advancement osteotomy was performed (utilising mini-implant intermaxillary fixation) to correct the traumatic overbite, followed by limited alignment and levelling of the lower buccal segments. This required intrusion of the over-erupted upper left canine.
- 1.5mm diameter, 6mm length, short neck Infinitas mini-implants were fully inserted on the buccal aspect mesial and distal to the upper left canine. Elastomeric traction was applied to a cleat on the canine's labial surface (Figs 9.2b, c). By 16 weeks the canine had been vertically over-corrected, without labial crown tipping. The canine was allowed to settle into occlusion as the lower buccal teeth were extruded using a box elastic from the mini-implants (Figs 9.2d, e).

2. Incisor teeth intrusion case (Fig. 9.3)

- A 24 year old female with a Class II division 2 malocclusion with absent upper right first premolar and left canine teeth, and a history of aggressive juvenile periodontitis (Fig. 9.3a). She required periodontal stabilisation, then alignment and intrusion of the over-erupted upper incisor teeth and the creation of inter-incisal clearance for a bonded retainer.
- The maxillary arch was levelled to accommodate a 0.019 × 0.025 NiTi archwire then 1.5mm diameter, 9mm length, short neck Infinitas mini-implants were inserted on the buccal aspect of the arch, distal to the upper lateral incisors and close to the MGJ. Light elastomeric traction was applied for 6 months, initially to the lateral and then to the central incisor brackets (Figs 9.3b, c). The later traction vector was more oblique to limit labial crown tipping. The periodontal status and overbite remained stable as seen over four years after debond (Fig. 9.3d).

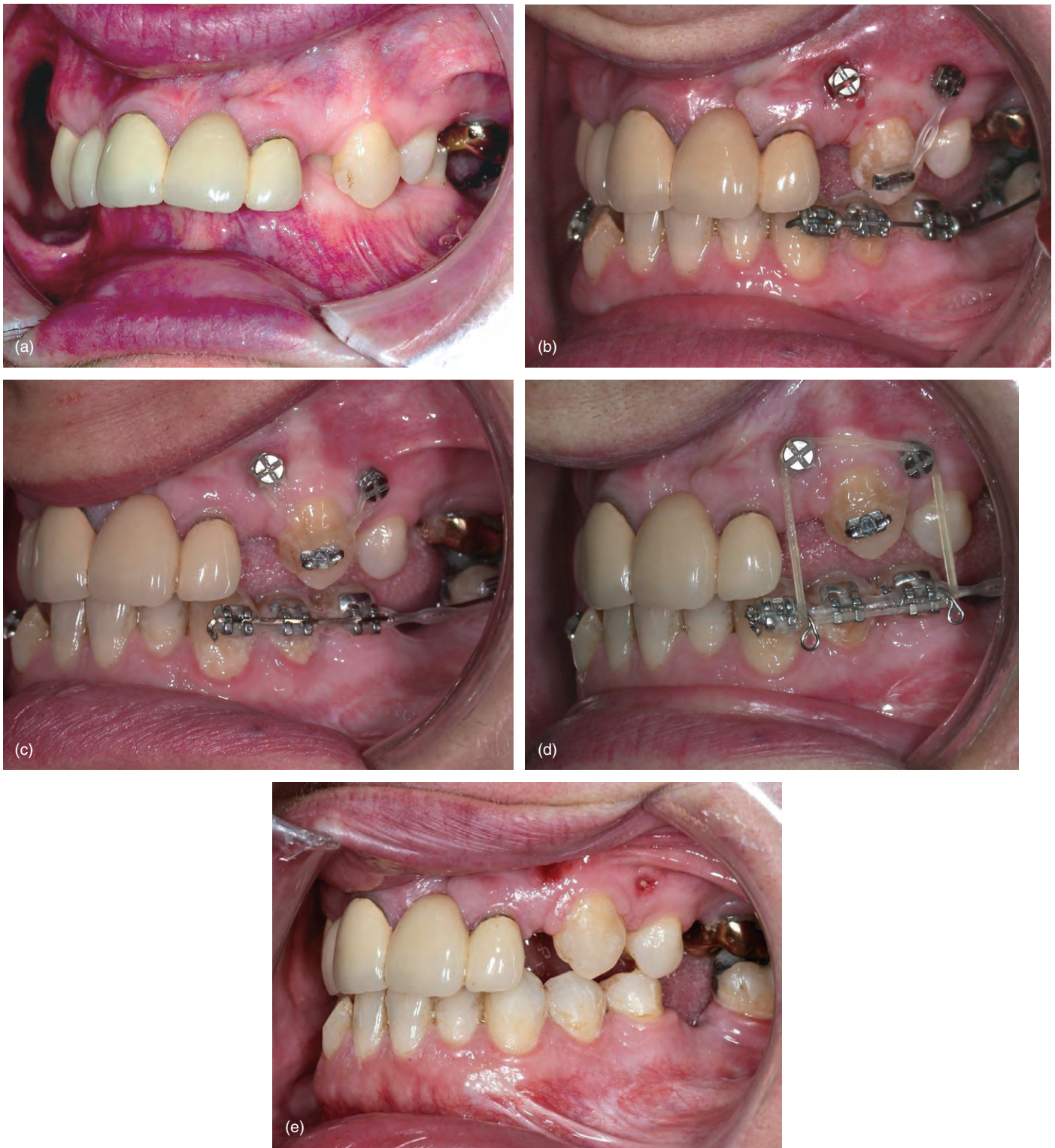


Figure 9.2 (a) Pre-treatment views showing this severe Class II division 1 malocclusion complicated by over-eruption of the maxillary left canine and inadequate dental support for formal fixed appliance treatment. (b) The upper left canine at the start of its intrusion, following a mandibular advancement osteotomy to correct the Class II discrepancies. Elastomeric traction is applied from mesially and distally sited 6mm length mini-implants to a low profile cleat. This intrusion will enable the lower buccal teeth to be levelled. (c) The canine intrusion is progressing by eight weeks and (d) by sixteen weeks its level has been over-corrected, without buccal tipping. A vertical box elastic is then added to extrude the lower teeth. (e) Debond view, accepting incomplete occlusal interdigitation.



Figure 9.3 (a) Pre-treatment view showing the over-erupted upper left central incisor, absence of the upper right first premolar and left canine teeth, and anterior spacing. (b) Vertical traction from bilateral mini-implants, inserted at the mucogingival junction, with a 0.019 × 0.025 steel archwire. (c) View of aligned teeth and the improved gingival contour during treatment, and then (d) four years after debond.

ANTERIOR OPENBITE TREATMENT

Anterior openbite (AOB) is one of the most difficult malocclusion features to treat non-surgically. Traditional orthodontic camouflage tends to extrude the incisors, but this has several key disadvantages: the risk of excessive upper incisor exposure (crown length display); unfavourable incisor retroclination; an unaesthetic effect on the nasolabial profile and smile; and a particularly high relapse risk (partly due to practical difficulties in retention).^{4,5} There is also a greater tendency to prescribe premolar extractions in AOB cases with the aim of limiting incisor proclination and consequently vertical incisor separation. Furthermore, it is claimed that premolar extractions enable mesial movement of the molars and

consequently reduce the maxillo-mandibular planes angle (MMPA), but this is not supported by research evidence.⁶ Therefore, extraction decisions should be based on dental factors such as crowding and centreline discrepancies, rather than the AOB per se. The alternative of surgical impaction of the posterior maxilla is effective, but it involves invasive and expensive treatment, it must be delayed until after completion of facial growth, and it entails surgical morbidity and risks, and possibly unfavourable nasal changes. How much better would it be to both correct the AOB and improve dentofacial aesthetics by a more effective and patient-friendly approach?

Mini-implant molar intrusion now represents a real alternative to orthognathic surgery in Class I and II

skeletal AOB cases (but not in skeletal Class III patients where mandibular autorotation would worsen the antero-posterior relationship). In effect, clockwise rotation of the maxillary occlusal plane causes a reduction in both the MMPA and AOB.^{7,8,9,10,11} Crucially, intrusion treatment is feasible in both adults and adolescents, and avoids the surgical morbidity and in-patient costs associated with a maxillary osteotomy. Over the last few years I have given those AOB patients, whom I think may benefit from orthognathic surgery, the opportunity to discuss the options fully on a combined orthognathic clinic: none have opted for surgery on the basis of their AOB problems, and some have been desperate to avoid surgery even accepting residual Class II facial features. I find this to be genuine informed consent and would advise that such patients are given details of all options open to them. In my experience, none have regretted taking a non-surgical approach.

Intrusion treatment is feasible in both adults and adolescents, and avoids the surgical morbidity and in-patient costs associated with a maxillary osteotomy.

After first utilising buccal mini-implant sites, I have found palatal insertion sites to be much more effective for maxillary molar intrusion in terms of the greater availability of interproximal space, sufficient cortical bone support and range for vertical traction.¹² Consequently, the clinical steps outlined here describe the culmination of this experience with palatal mini-implants combined with an intrusion transpalatal arch (TPA) or quadhelix.

Clinical objectives

- Intrusion of the maxillary, and possibly the mandibular, molars to correct an AOB (and Class II discrepancies where present).
- Counter-clockwise mandibular autorotation.

Treatment options

- Molar intrusion using mini-implant anchorage.
- Headgear to limit vertical maxillary dentoalveolar growth.
- Functional (orthopaedic) appliances or posterior bite blocks.
- Premolar or molar extractions to facilitate incisor retraction.

- Reverse curve archwires and intermaxillary elastics.
- Maxillary impaction osteotomy.

Relevant clinical details

- The incisor (overjet, openbite) and buccal segment relationships.
- Upper incisor vertical display (passive and smiling exposure).
- Whether vertical facial asymmetry and an occlusal cant are present.
- Whether there is a vertical step in the occlusion between the anterior and posterior teeth and/or potential occlusal interferences from palatally displaced teeth.
- Eruptive status of the second and third molars.
- Transverse molar relationships, i.e. would mandibular clockwise rotation cause posterior crossbites?

Biomechanical principles

- Buccal mini-implants may provide only a limited range of intrusion in many patients because of a limited height of attached gingiva (and allowing for subsequent apical movement of the molars).
- Posterior palatal alveolar insertion sites offer three advantages over buccal ones: greater height of attached mucosa, cortical bone thickness and interproximal bone volume.¹²
- Buccal or palatal intrusion forces cause undesirable transverse side-effects, i.e. buccal crown rolling or arch constriction, respectively. Therefore, the transverse arch width and molar torque should be controlled either by a rigid TPA (Fig. 9.4), or by

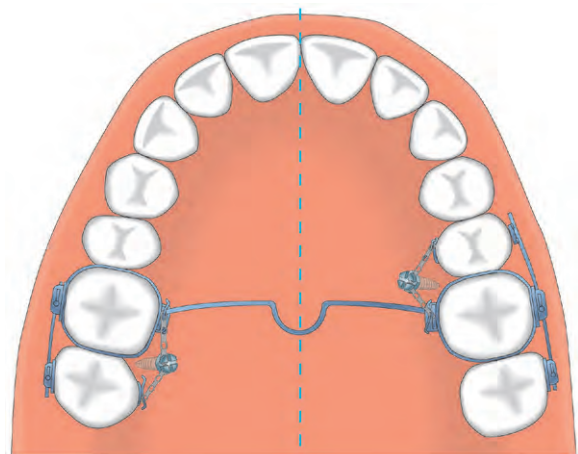


Figure 9.4 Diagram of palatal mini-implants inserted mesial and distal to the first molar palatal root, and traction to a TPA and palatal attachments.

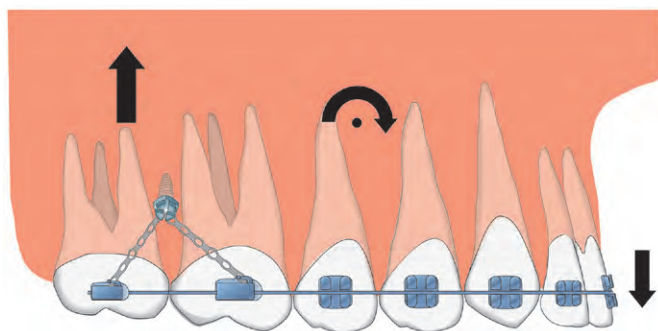


Figure 9.5 Diagram showing the biomechanical side-effects of posterior intrusion where rotation of the entire maxillary arch also results in extrusion of the incisors.

simultaneous buccal and palatal mini-implant traction.

- Molar intrusive movements, especially with traction applied distal to the second molars, may cause the entire dental arch to tip around its centre of rotation (in a clockwise direction in the maxilla), causing inadvertent incisor extrusion (Fig. 9.5). This is countered by the use of segmental mechanics (separate buccal and labial segments) or the addition of a bite-opening curve to any steel archwires used during continuous arch mechanics.

Clinical tips and technicalities

- Consider removal of erupted third molars (prior to orthodontics) since they may cause occlusal interference after intrusion of adjacent molars.
- Increase the maxillary inter-molar and canine widths at the start of treatment, to allow for the combined effects of both mandibular autorotation and to counteract the constrictive effects of palatal traction. If in any doubt err towards over-expansion since it is easy to allow this to settle later in treatment, whereas it is difficult to simultaneously intrude and expand molars at the finishing stages of treatment (when relatively light wires may be more ideal). I've found that a standard removable quadhelix, with some simple modifications to keep the loops clear of the mini-implant sites and palate, can be used for expansion and then to connect the intrusive traction to the first molars from mini-implants inserted on their distal side (Fig. 9.6).
- Mini-implant insertion mesial to the first molars is more accessible (for both insertion and traction application), is appropriate in adolescents with partial or non-eruption of the second molars, and produces little clockwise maxillary arch rotation. Alternatively,

insertion distal to the first molars is feasible in adults, and gives more ability to directly intrude and control the inclination (torque) of the second molars.

- Palpate the soft tissue at the potential insertion sites to check that it is firmly attached, rather than feeling mobile (as an extension from the soft palate tissues) or excessively viscoelastic. This may occur in adolescent patients where the soft tissue on the posterior aspect of the palatal alveolus may not be tightly attached to the periosteum or it moves with soft palate movement. In this case, plan for the mini-implants to be mesial to the first molars.
- Pre-plan whether sectional (molar) (Figs 9.6b, c) or full arch fixed appliance engagement is optimal at the start of treatment. For example, palatally displaced teeth, such as canines or lateral incisors, may require early alignment in order to avoid them causing occlusal interference during AOB closure (Figs 9.6d, e).
- Use of a speed reduction contra-angle handpiece (rather than a manual one) and a guidance stent greatly facilitate palatal insertions where access is usually restricted.
- If it is unnecessary to bond the mandibular arch during the initial intrusion phase then consider provision of a lower vacuum-formed retainer to prevent over-eruption of the lower molars (as the upper ones intrude). If the lower arch is bonded then include the second molars, again to stabilise their vertical position.
- If the TPA needs to be removed, to facilitate final alignment and levelling (using a molar tube on the first molars), then some vertical relapse of the first molar may occur if there is a step between it and the adjacent teeth. This may be counteracted by bonding an attachment onto the palatal surface of the first molar and applying light elastomeric traction or a ligature from the mini-implant for vertical retention. If there is a risk of crossbite development, due to the constrictive effects of further intrusive traction, then a double tube bonded on the molars provides the option of adding an auxiliary buccal expansion wire.

Increase the maxillary inter-molar and canine widths at the start of treatment, to allow for the combined effects of both mandibular autorotation and to counteract the constrictive effects of palatal traction.



Figure 9.6 (a) An adult male with a Class II division 1 malocclusion, and AOB and absent upper first premolars. (b) A quadhelix was used for initial maxillary arch expansion and a sectional fixed appliance fitted involving the first and second molars before (c) insertion of bilateral posterior palatal mini-implants provided for intrusive traction on the quadhelix. (d, e) The anterior teeth were bonded when premature contact on the right canines became problematic. (f) Final space closure and centreline corrections, four months after removal of the quadhelix and palatal traction.

Simultaneous mandibular molar intrusion

The maxilla is the predominant source of excessive vertical alveolar height in most AOB cases, but mandibular molar intrusion may also be beneficial for large AOB corrections and if there is a reverse curve of Spee in the lower arch (Fig. 9.7). Pre-planned mandibular intrusion includes transverse control with a lingual arch using the following steps:

- Preparation: take an impression, lower molar periapical radiographs and place inter-molar separators.
- Fabricate a lingual arch for the first molars (to control molar arch width/torque).
- Insert bilateral lower molar mini-implants (1.5mm diameter, 6 or 9mm length, short neck) either mesial or distal to the first molars.
- Apply 'V' shaped traction to the adjacent hooks/brackets, using the same principles as for maxillary intrusion.

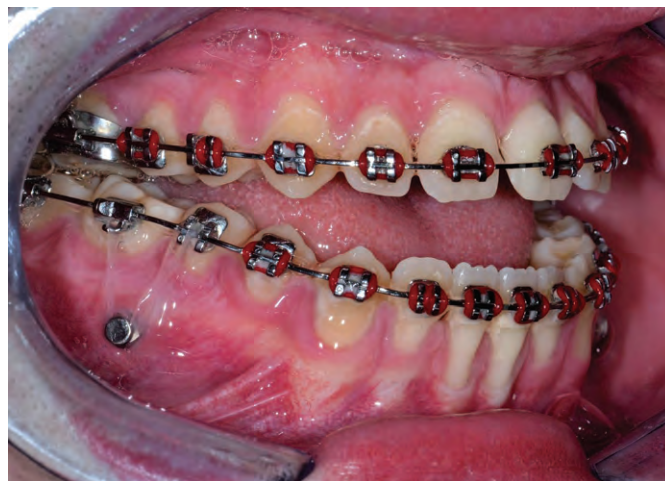


Figure 9.7 (a) Mandibular buccal intrusion, supplementing maxillary arch intrusion, where there is a reverse curve of Spee in the mandibular arch. Traction is applied as a 'V' configuration from the mini-implant to the premolar and molar attachments.

Clinical steps for maxillary molar intrusion

Pre-insertion

1. Expand the maxillary arch where necessary to facilitate future arch coordination.
2. Band the upper first molars (and record the band sizes) at the start of treatment. Select a band size which enables full seating of the band and allows for any band constriction during TPA fabrication. This makes it easier to ensure that the second molar tube tends towards being at a more occlusal level than the first molar one.
3. Bond molar tubes on fully erupted upper second molars. The avoidance of molar bands facilitates effective gingival hygiene at the posterior limit of the dental arch where a reduction in crown height may occur and toothbrush access is most limited.
4. If the second molars are not fully erupted (in an adolescent) then do not bond them during initial alignment. Instead, plan to insert the mini-implants mesial to the first molars, and if the interproximal space appears limited then diverge the second premolar and first molar roots by adding mesial tip to the premolar bracket at bond-up. This causes the premolar root to move mesially during initial alignment (and the tip can readily be corrected at the treatment finishing stage).
5. Level and align either the whole maxillary dentition or only the posterior teeth adjacent to the mini-implant insertion sites using sectional fixed appliances. This decision depends on the extent of the vertical discrepancy between the anterior and posterior teeth, where a large step favours segmental mechanics; whilst the risk of occlusal interferences from displaced anterior teeth necessitates full arch alignment.
6. When a 0.019 × 0.025 NiTi archwire has been inserted book two clinical appointments (assuming use of 0.022 slot brackets).
7. At the preparatory appointment take an alginate impression for fabrication of the TPA (leaving the original molar bands in situ), and a second impression for a guidance stent. New molar bands are placed in the impression for TPA fabrication.
8. Evaluate the positions of the molars' palatal roots on the dental model and ideally with peri-apical radiographs (or even a sectional CBCT).

Intrusion TPA fabrication (Fig. 9.8)

9. Cast two working models – one with bands on the first molars (for TPA fabrication) and one for stent fabrication.
10. A 1.0mm diameter stainless steel wire is used to make the TPA rigid. Its lateral ends are curved posteriorly to form a short hook extending 3mm distal to the molar band (Fig. 8a). The wire is soldered to the *mesio-palatal* corner of the first molar bands, rather than the standard mid-band position. This allows easy access between the TPA and the mini-implant heads.
11. Conversely, if the mini-implants are to be inserted mesial to the first molars, then the mesio-distal offset position of the TPA bar is reversed (Fig. 9.8b).
12. Bilateral short (3mm) anterior hooks are added to the TPA by soldering 1.0mm wire onto the mesio-palatal aspect of the molar bands (Fig. 9.8c).
13. The palatal bar must be offset from the palate, e.g. by 5mm in the midline, to allow for its gradual vertical displacement during treatment. It must also have adequate clearance from the lateral aspects of the palatal alveolar tissues (Fig. 9.8c).
14. The mid-palatal loop should be wider than usual to provide a broader area of tongue contact, and hence reduce tissue discomfort.

Mini-implant selection

15. Maxilla: use a long neck version to allow for the relatively thick mucosal tissue, e.g. for Infinitas use a 1.5mm diameter, 9mm length, long neck one. If the palatal tissues are particularly thick or have a spongy texture, or the patient is still undergoing considerable somatic growth, then a 2mm diameter version may be indicated to give maximum primary stability without full depth intra-bony insertion.
16. Mandible: body length selection depends on the anticipated cortical depth and density such that a long length (9mm) version is preferable for adolescent patients, where the cortical support is reduced. An Infinitas 1.5mm diameter, 6mm length, short neck version may be used in an adult.

Insertion

17. Superficial anaesthesia of the insertion sites, i.e. blanch the area overlying the first and second molar interproximal space. Topical anaesthetic may be applied prior to local anaesthesia, but it is probably insufficiently effective on its own for such thick soft tissue.
18. Fit the stent (if available).
19. Use a mucosal punch to remove a circular section of the thick gingival tissue. After the surface has been marked with the stent in situ, temporarily remove it so that the mucotome can be applied perpendicular to the surface, providing a clean cut of the tissue. If necessary, then remove the mucosal tissue with a Mitchell's trimmer or mosquito forceps.
20. In adults, use a cortical bone punch to perforate the relatively dense thick palatal cortex.
21. Insert bilateral mini-implants on the palatal side of the alveolus, using a speed-reducing (e.g. 128:1 ratio) contra-angle handpiece at less than 100rpm.
22. Take an intra-oral radiograph if close root proximity is clinically suspected, especially if an adjacent tooth is tender on percussion.
23. Complete insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible.

Post-insertion

24. Cement the intrusion TPA on the first molars.
25. Traction is applied from the mini-implants to the TPA, either as an 'L' or 'V' configuration (Fig. 9.9a). The latter is more difficult to pass around (under) the TPA but is less prone to occlusal interferences.
26. Apply approximately 50g (elastomeric chain) traction to the TPA hooks for the first four to six weeks. Subsequently use a stronger (150–200g) elastomeric or NiTi closing coil auxiliary.
27. Monitor treatment progress by recording the following features at the start of intrusion and at subsequent appointments: overjet, AOB/overbite, canine relationship, the upper incisor display (at rest and on full smiling), any molar openbite, and the TPA's proximity to the palate.
28. Monitor the periodontal condition (probing depth) of the terminal molars.
29. If appropriate, add a curve of Spee to the 0.019 × 0.025 stainless steel archwire to minimise incisor extrusion (as the maxillary occlusal plane rotates clockwise).
30. If necessary, in a large AOB case, replace the TPA when it contacts the palatal mucosa (although fortunately in my experience patients don't complain of pain when this occurs).
31. Over-correct the AOB changes to allow for possible molar relapse.
32. After the main intrusion phase, either section the TPA or remove it altogether and bond buccal molar tubes. Consider the use of double tube attachments since this provides the option of adding an auxiliary buccal archwire (e.g. 0.019 × 0.025 steel) for molar expansion (Fig. 9.10). This may be particularly beneficial if the main archwire needs to be a flexible NiTi one for alignment purposes; or occasionally if a TPA is not well tolerated at the outset (as occurred in the case shown in Fig. 9.10, where the palatal gingival tissues were prone to a hyperplastic response).
33. Keep the mini-implants in situ until it is clear that further anchorage is not required. If later vertical control is needed then run traction to attachments bonded to the molar palatal surfaces (Fig. 9.9b). Notably, the constrictive side-effects would need to be balanced by generous archwire expansion (hence the benefit in double molar tubes).
34. Consider an initially intensive retention regimen, e.g. three months full-time wear of plastic retainers with whole arch occlusal coverage. These should prevent early molar extrusion after debond.

If appropriate, add a curve of Spee to the 0.019 × 0.025 stainless steel archwire to minimise incisor extrusion (as the maxillary occlusal plane rotates clockwise).

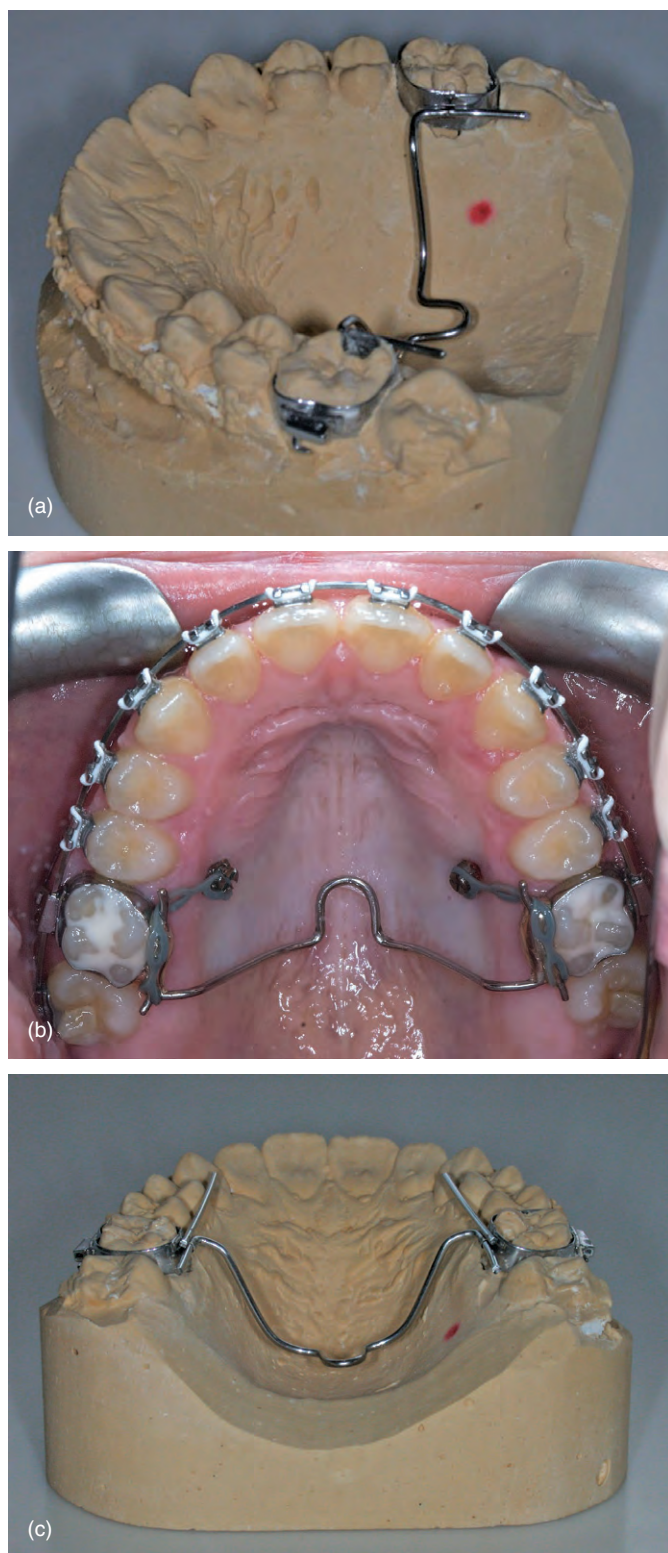


Figure 9.8 (a) Fabrication of a customised intrusion TPA where the wire is mesially offset to be clear of the mini-implant site (indicated by a red mark). (b) Distally offset TPA, allowing for mini-implants inserted mesial to the first molars. (c) 5mm palatal clearance of the middle TPA section, plus of the TPA flanks (from the palatal alveolus).

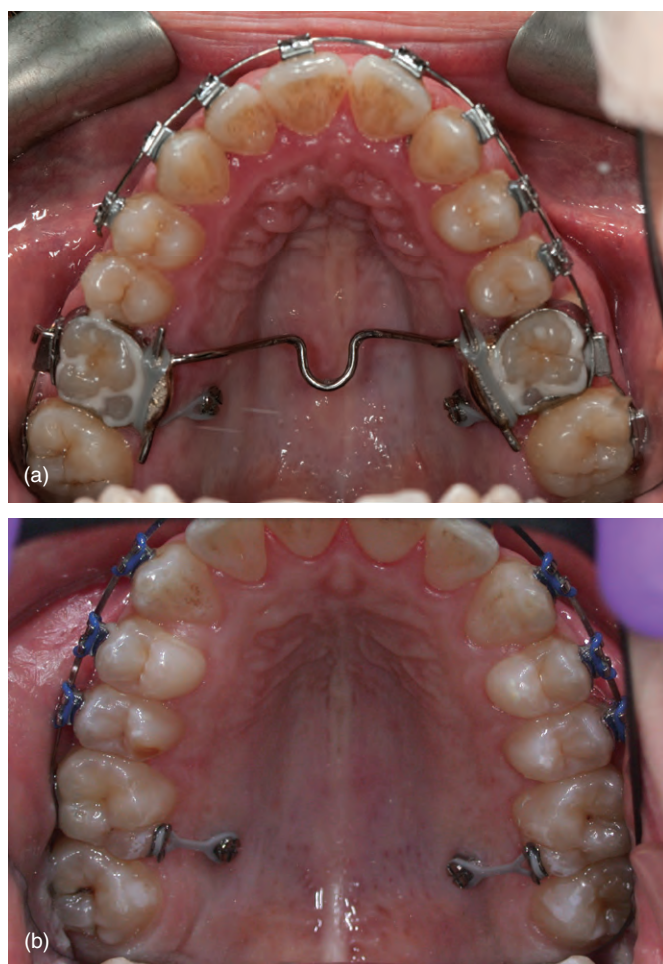


Figure 9.9 (a) 'L' shape of elastomeric traction to the intrusion TPA. (b) Traction from palatal mini-implants to bilateral molar cleats.



Figure 9.10 (a) Addition of a buccal expansion wire (0.019 x 0.025), using the auxiliary molar tubes.

CASE EXAMPLES**1. Molar intrusion: example one (Fig. 9.11)**

- A 28 year old female presenting with a Class II division 1 malocclusion on a moderate skeletal II base with a 40° MMPA (Figs 9.11a–d). She had absent first premolars, a 9mm overjet and 8mm AOB, and a satisfactory upper incisor display. Bimaxillary surgery was declined as the preferred treatment option.
- The maxillary arch was aligned and levelled, resulting in a 2mm reduction in the AOB. Mini-implants were inserted distal to the first molars and an intrusion TPA fitted (Figs 9.11e, f). Once progressive molar intrusion was evident the patient confirmed her preference to continue with non-surgical treatment and had her third molars surgically removed.
- A bite-opening curve was added to the upper 0.019 × 0.025 steel archwire to counter the rotational effect on the whole arch of posterior intrusion biomechanics, and this also assisted incisor torque improvements. The amount of archwire curvature was judged by monitoring the passive and active upper incisor display levels.
- The TPA was replaced once it was in (painless) contact with the mid-palate mucosa, then the second TPA was removed once a sufficient OB was present and asymmetric elastic traction was required for centreline correction (Figs 9.11g, h). At this stage there was a high gingival level around the second molars, but this tissue was healthy and remodelled in time.
- Treatment was completed with an aesthetic level of incisor display, a reduction in lower face height, easier achievement of lip competence and an improvement in the chin region's soft tissue contour (Figs 9.11i–k). These changes were primarily due to maxillary molar intrusion, mandibular autorotation and upper incisor retroclination (Fig. 9.11l).
- Vacuum-formed removable retainers were fitted and a stable overbite persisted one year after debond (Fig. 9.11m). However, right molar crossbites are evident (without mandibular displacement), which in hindsight could have been avoided by maxillary molar expansion at the start of treatment. The extent of mandibular autorotation achieved had not been anticipated in this case.

2. Molar intrusion: example two (Fig. 9.12)

- A 14 year old male with a Class III malocclusion on a mild skeletal II base with a 36° MMPA (Fig. 9.12a). There was a 3mm AOB, bilateral molar crossbites and moderate maxillary arch crowding.
- Treatment commenced with an upper fixed appliance and quadhelix for expansion, alignment and levelling (Fig. 9.12b).
- Mini-implants were inserted distal to the upper first molars and an intrusion arch replaced the quadhelix once the arch was aligned to take a 0.019 × 0.025 NiTi archwire (Figs 9.12c, d). An 'L' configuration of elastomeric traction was applied to the TPA.
- Right class III elastic traction was added to assist with incisor relationship and centreline corrections (Fig. 9.12e), but upper molar extrusion was avoided by the continued mini-implant traction.
- The TPA was removed to enable final molar alignment (Fig. 9.12f), whilst the mini-implants remained until treatment was completed, in case further traction was required. No anterior elastics were used, and a residual centreline discrepancy was accepted, due to limited compliance with the asymmetric elastic (Fig. 9.12g).

3. Molar intrusion: example three (Fig. 9.13)

- A 19 year old male presenting with a Class 1 malocclusion on a skeletal I base with an increased MMPA (Figs 9.13a–c). He had absence of the upper right lateral incisor and short upper and lower incisor root lengths. There was a 2mm overjet, a 4mm AOB and a satisfactory level of upper incisor display. The upper and lower centrelines were displaced to the right and left sides, respectively (Figs 13d, e).
- The maxillary buccal segment was aligned, levelled and expanded using sectional fixed appliances and a quadhelix.
- Mini-implants were inserted distal to the first molars and an intrusion TPA fitted (Figs 9.13f, g). The TPA was replaced after it contacted the mid-palatal mucosa, without eliciting pain (Figs 9.13h, i).

- Intrusion was stopped when the incisors had a 1 mm OB and -2 mm OJ (Fig. 9.13j). The OB correction then relapsed slightly when traction was discontinued for extraction of the upper left second premolar and lower right first premolar teeth. These extractions provided space for correction of the developing Class III incisor relationship and the centreline discrepancies (Figs 9.13k, l).
- Conventional fixed appliance treatment continued in terms of space closure and right Class III elastic traction, then posterior box elastic settling for the final eight weeks.
- Treatment was completed with an aesthetic level of incisor display, a reduction in lower face height, easier achievement of lip competence and an improvement in the chin region's soft tissue contour (Figs 9.13m–p). These changes were primarily due to maxillary molar intrusion, mandibular autorotation and incisor retroclination (Figs 9.13q, r).

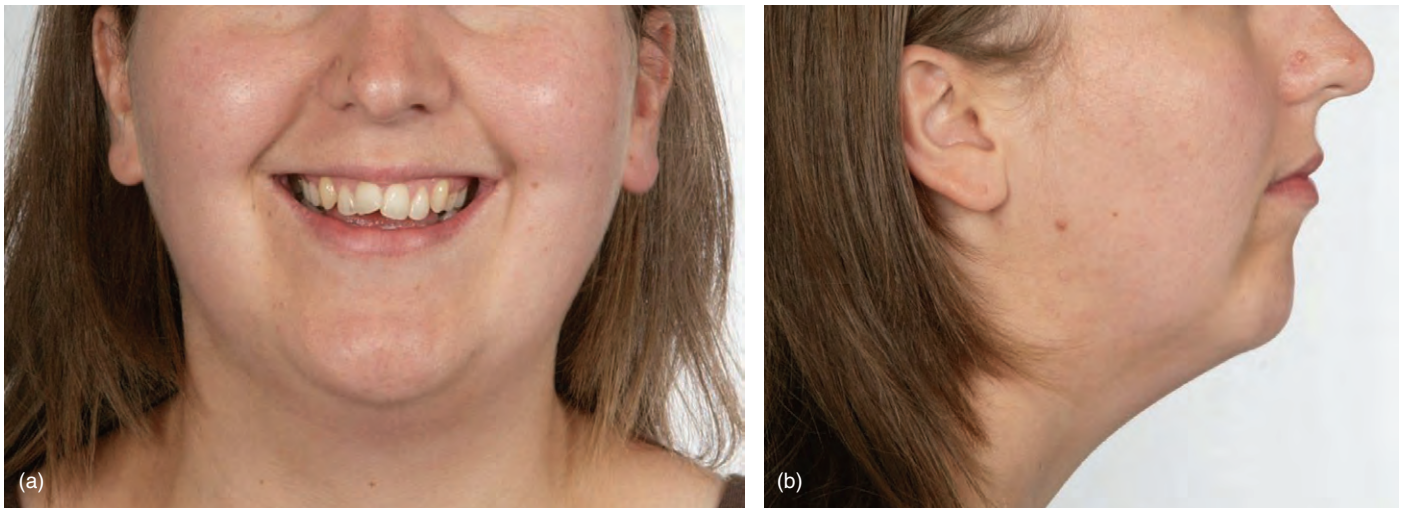


Figure 9.11 (a–d) Pre-treatment views showing Class II profile and skeletal relationship, high mandibular angle, AOB and appropriate upper incisor display. (b) Copyright The Royal College of Surgeons of England. Reproduced with permission. (e, f) Full upper fixed appliance with intrusion TPA and palatal mini-implants (sited distal to the first molars) (f) Copyright The Royal College of Surgeons of England. Reproduced with permission. (g, h) Following correction of the AOB, the TPA is removed, but the mini-implants still provide the option of direct molar traction. A right Class II elastic is being used for centreline correction, with its vertical effect counteracted by a right bite-opening curve. (i–l) Debond views with a pleasing overbite and aesthetic incisor display, accepting right molar crossbite (given absence of a mandibular displacement). (m) Cephalometric superimposition of the total treatment changes (red pre-treatment, green post-debond), showing the maxillary molar intrusion, incisor levelling, incisor relationship changes and mandibular autorotation effects.

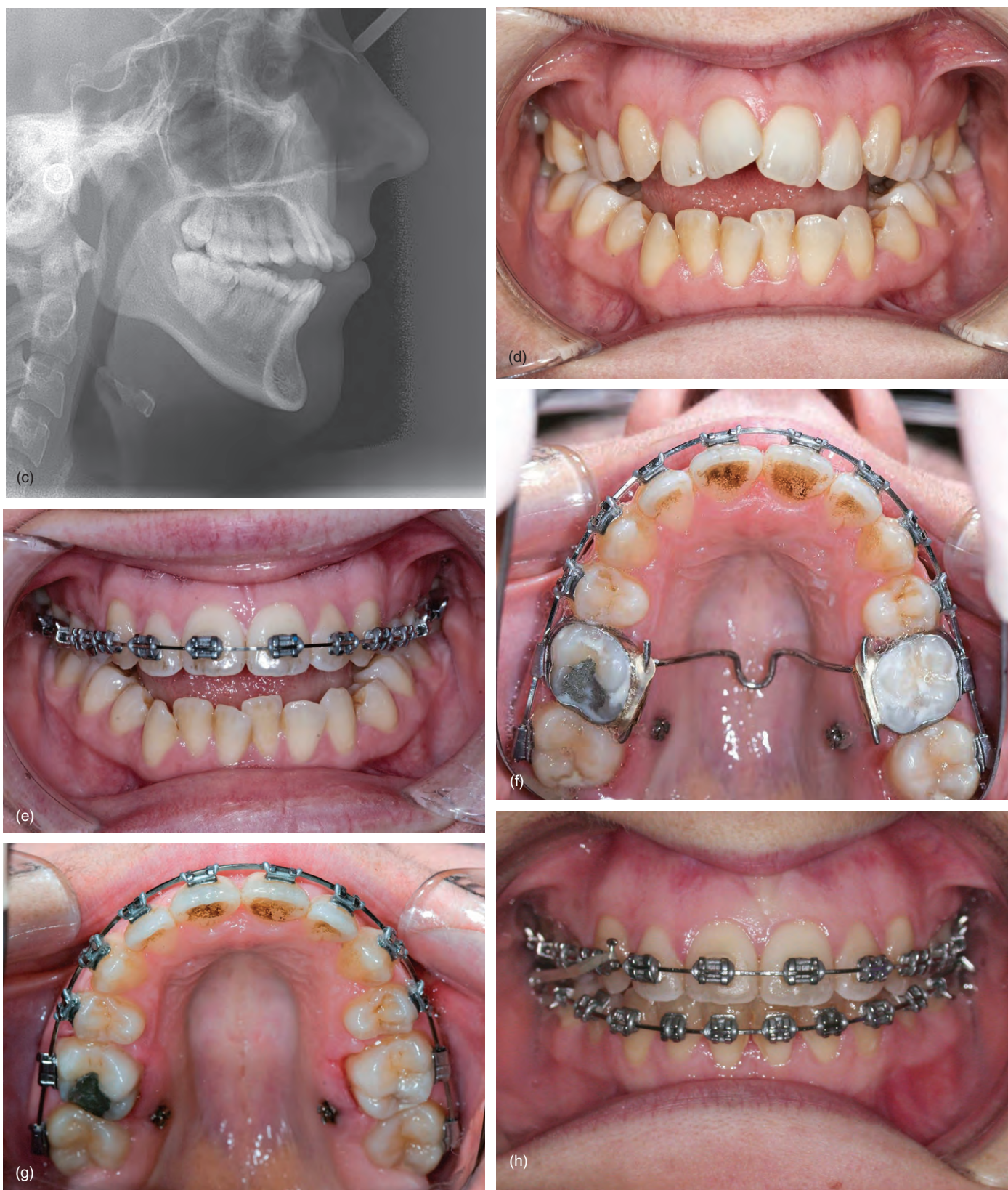


Figure 9.11 *Continued*

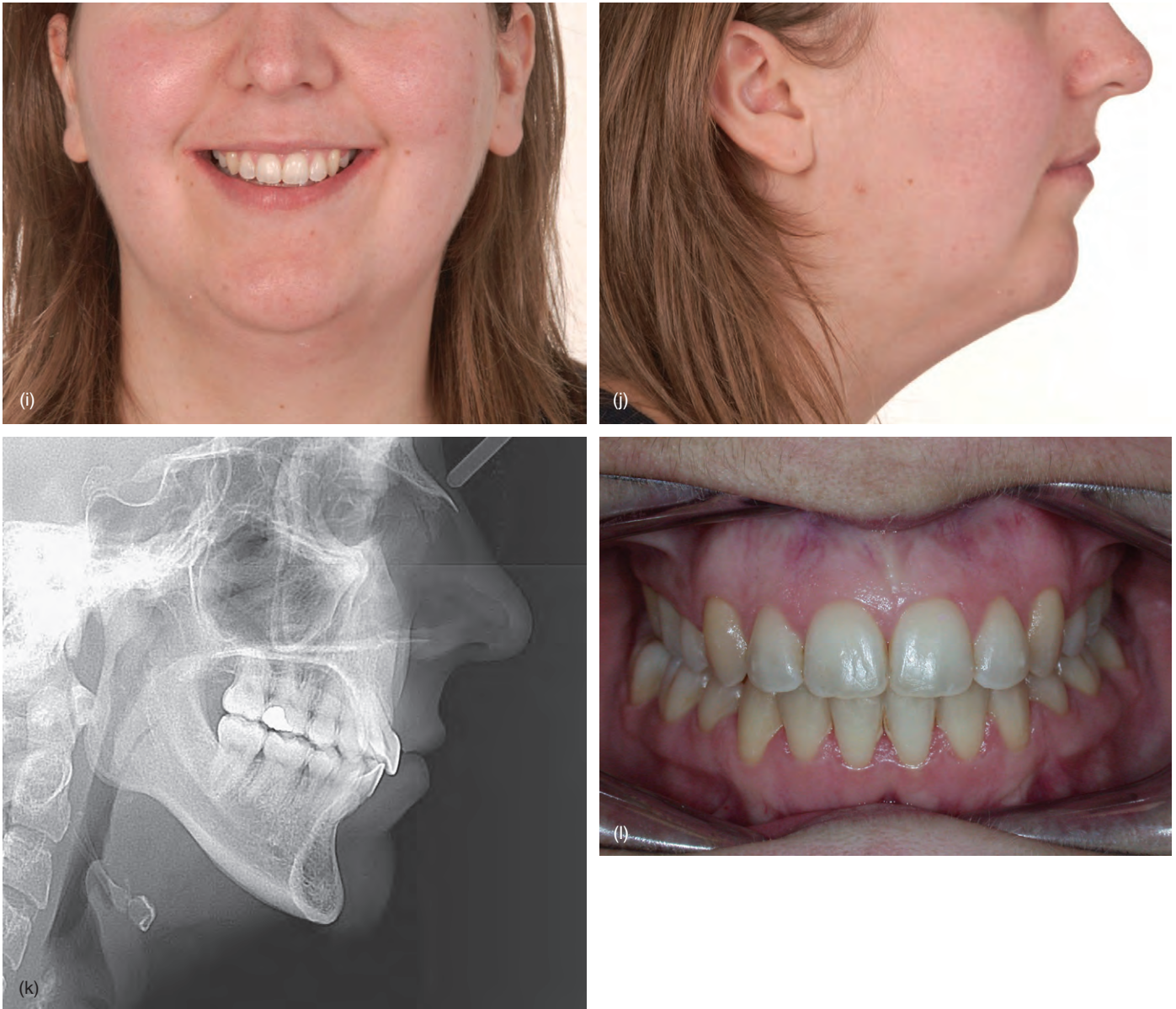


Figure 9.11 *Continued*

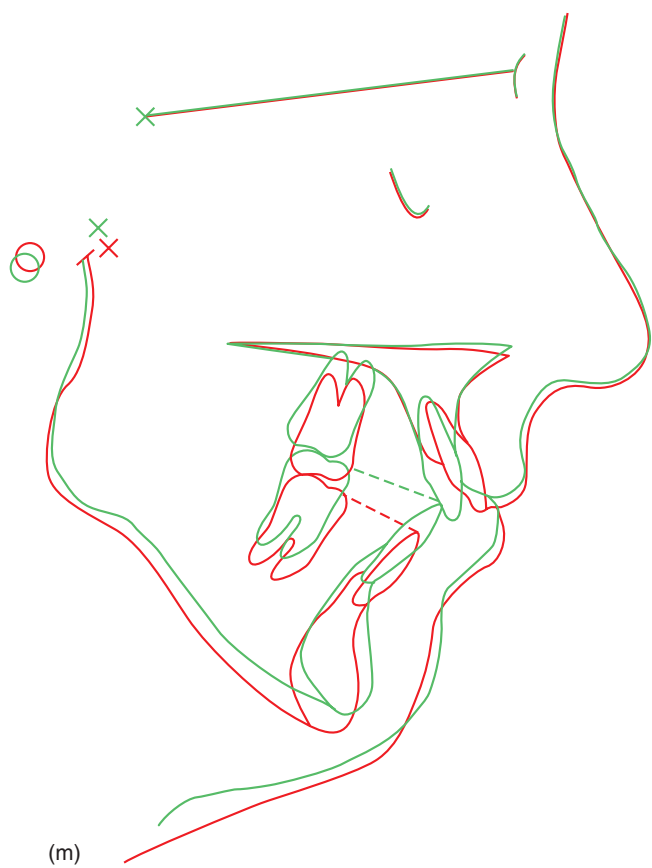


Figure 9.11 Continued

SKELETAL			SOFT TISSUES		
SNA	°	0.5	Lip Sep	mm	-1.0
SNB	°	0.5	Exp UI	mm	3.5
ANB	°	-0.5	LS-E	mm	-1.0
SN/MxP	°	-2.5	LI-E	mm	-2.0
MxP/MnP	°	0.5	NLA	°	-6.0
LAFH	mm	-3.0	LLA	°	-6.0
UAFH	mm	-1.5	Holdaway	°	-1.0
LAFH/TAFH %		-0.5	NOSE PROMINENCE		
LPFH	mm	-2.5	Nose tip	mm	0.5
UPFH	mm	0.5	Nose angle	°	-0.5
PFH	mm	-1.0	CHIN PROMINENCE		
Wits	mm	6.0	Chin tip	mm	4.0
TEETH			B-NPo	mm	0.0
Overjet	mm	-5.0	LADH	mm	1.5
Overbite	mm	11.0			
UI/MxP	°	-15.5			
LI/MnP	°	5.0			
IIangle	°	10.5			
LI-APo	mm	1.5			
LI-NPo	mm	1.5			



Figure 9.12 (a–d) Pre-treatment view showing the Class III malocclusion, AOB, and bilateral anterior and posterior crossbites. (b) Upper fixed appliance and quadhelix appliances, involving bands on the first molars and tubes on the second molars. (c, d) Start of molar intrusion phase, following maxillary arch expansion, levelling and alignment. Mini-implants are sited palatal and distal to the first molars, and there is an intrusion TPA in place. (e, f) Following removal of the intrusion TPA right Class III traction is being used for lower incisor and right canine retraction, and centreline correction. (g) Debond view, accepting a residual centreline discrepancy due to limited compliance.



Figure 9.12 *Continued*

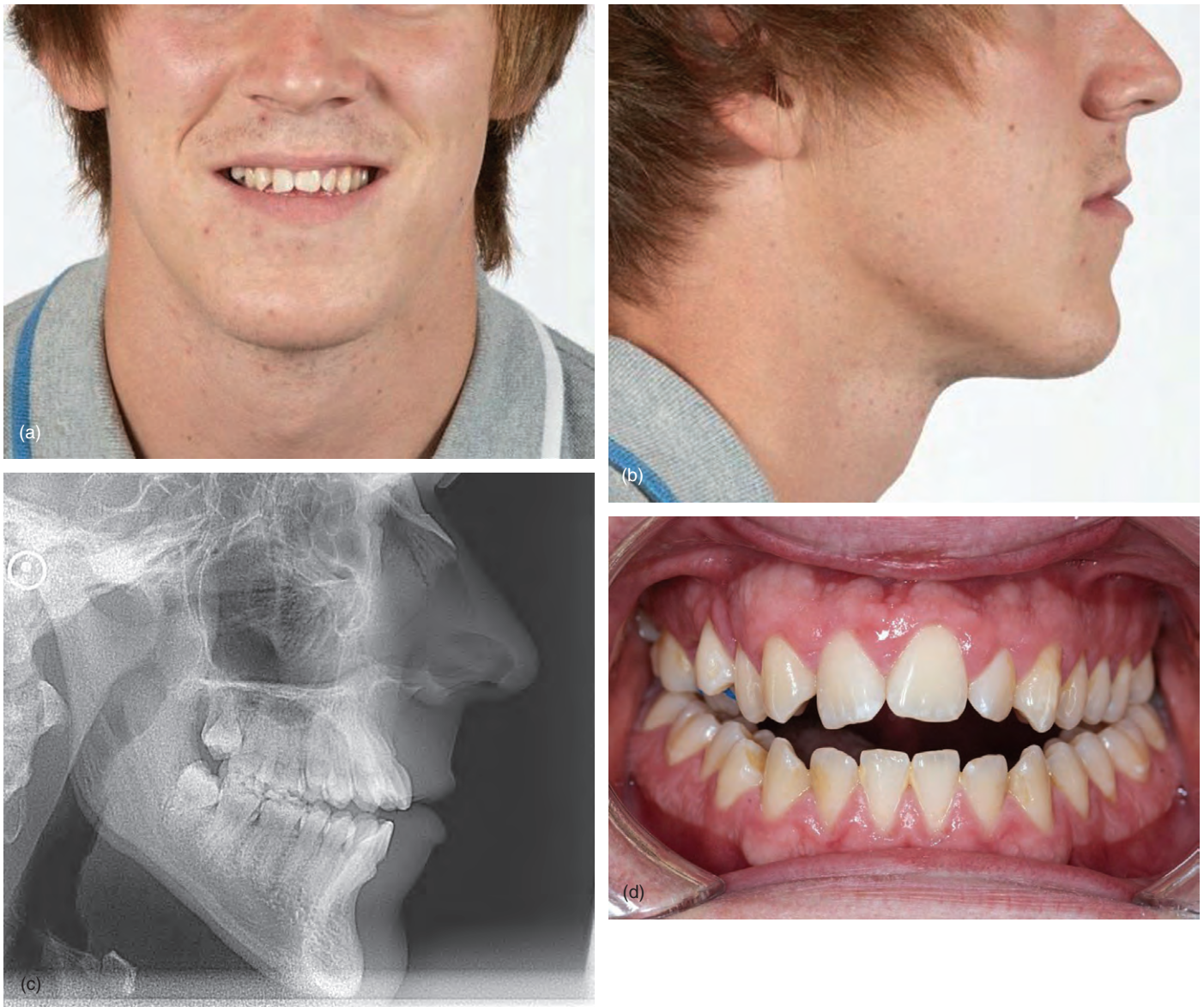


Figure 9.13 (a–e) Pre-treatment views showing the Class III malocclusion and facial profile, the AOB, absent upper right lateral incisor and centreline discrepancy. (f, g) Start of molar intrusion, after levelling and alignment of the premolar and molar teeth, and insertion of an intrusion TPA and palatal mini-implants (distal to the first molars). (h, i) Full upper arch engagement, excluding the left second premolar (planned for extraction). (j, k) The accentuated Class III incisor relationship is seen at the start of lower arch space closure (following extraction of the first premolars for incisor retraction purposes). (l) Removal of the TPA at the end of the intrusion phase and prior to upper arch space closure. (m–q) Debond views, showing AOB, Class III and upper centreline corrections. Over-corrections of the molar intrusive changes remain (to settle in retention). (r) Cephalometric superimposition showing total treatment changes e.g. maxillary molar intrusion, mandibular rotation and incisor retroclinations.



Figure 9.13 *Continued*



Figure 9.13 *Continued*

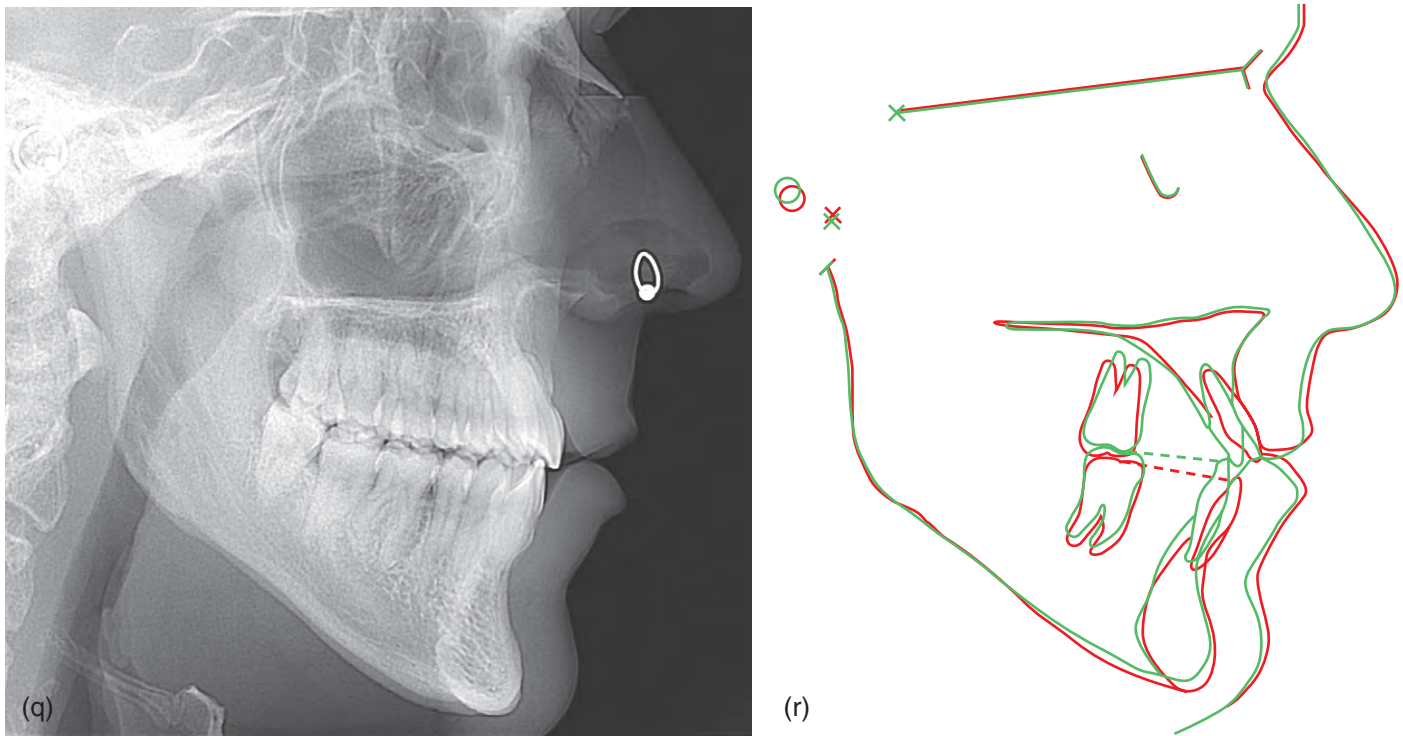


Figure 9.13 *Continued*

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Transverse and Asymmetry Corrections

Asymmetry problems

Mini-implant anchorage is invaluable for the correction of substantial asymmetry problems in all three planes of space, especially since it is now feasible to alter vertical dentofacial asymmetries which would otherwise be accepted with standard treatment or deemed to require orthognathic surgery. Conventional antero-posterior anchorage reinforcement involves connections on both sides of the arch (e.g. a TPA), which may be unnecessary, and even contra-indicated when fundamentally different movements are required in each quadrant. In comparison, mini-implant usage means that anchorage is only reinforced in the specific quadrant and direction(s) indicated for optimal treatment changes. For example, full correction of a large dental centreline displacement to the right side of the facial midline may require a unilateral mini-implant placed mesial to the upper left first molar (Fig. 10.1a). Furthermore, in such cases unilateral mini-implant anchorage helps with treatment efficiency by enabling 'multi-tasking', e.g. alignment of a palatally displaced lateral incisor at the same time as fully active bodily retraction of the contralateral canine (Fig. 10.1b) or space closure in the contralateral quadrant. This chapter describes unilateral mini-implant usage for the following applications:

- centreline (transverse) correction
- unilateral intrusion (vertical asymmetry correction)
- ectopic tooth alignment (transverse correction).

Mini-implant usage means that anchorage is only reinforced in the specific quadrant and direction(s) indicated for optimal treatment changes.

DENTAL CENTRELINE CORRECTION

Clinical objective

- Asymmetrical anchorage reinforcement to facilitate unilateral movement of the incisor teeth.

Treatment options

- Unilateral posterior (direct) mini-implant anchorage.
- Indirect mini-implant anchorage, e.g. stabilisation of a Nance palatal button so that unilateral traction can be applied from a molar band (as described for bilateral traction in Chapter Six).
- Conventional anchorage involving bilateral intra-oral reinforcement or asymmetric headgear.
- Asymmetrical intermaxillary elastic traction.
- Asymmetrically activated functional (orthopaedic) appliances.

Relevant clinical details

- Many patients display asymmetry in several dimensions rather than just one, although one



Figure 10.1 A Class III case requiring extraction of the upper right canine (at risk of labial dehiscence) and left first premolar teeth, maxillary arch alignment and centreline correction prior to orthognathic surgery. (a–c) Pre-treatment views showing the Class III malocclusion, palatal exclusion of the upper right lateral incisor and left Class II canine relationship. (d–f) Traction applied from a mini-implant, inserted mesial and buccal to the upper left first molar, to a powerarm bonded on the left canine crown. Simultaneous alignment of the right lateral incisor commences, with a combination of 0.018 steel base archwire and 0.012 piggyback sectional NiTi. (g, h) Bodily distalisation of the canine continues when a 0.018 NiTi archwire is used for further lateral incisor alignment. (i–k) Leftwards incisor traction applied in addition to canine movement, on insertion of a 0.019 × 0.025 NiTi archwire, without rollercoaster bowing of the left buccal teeth.

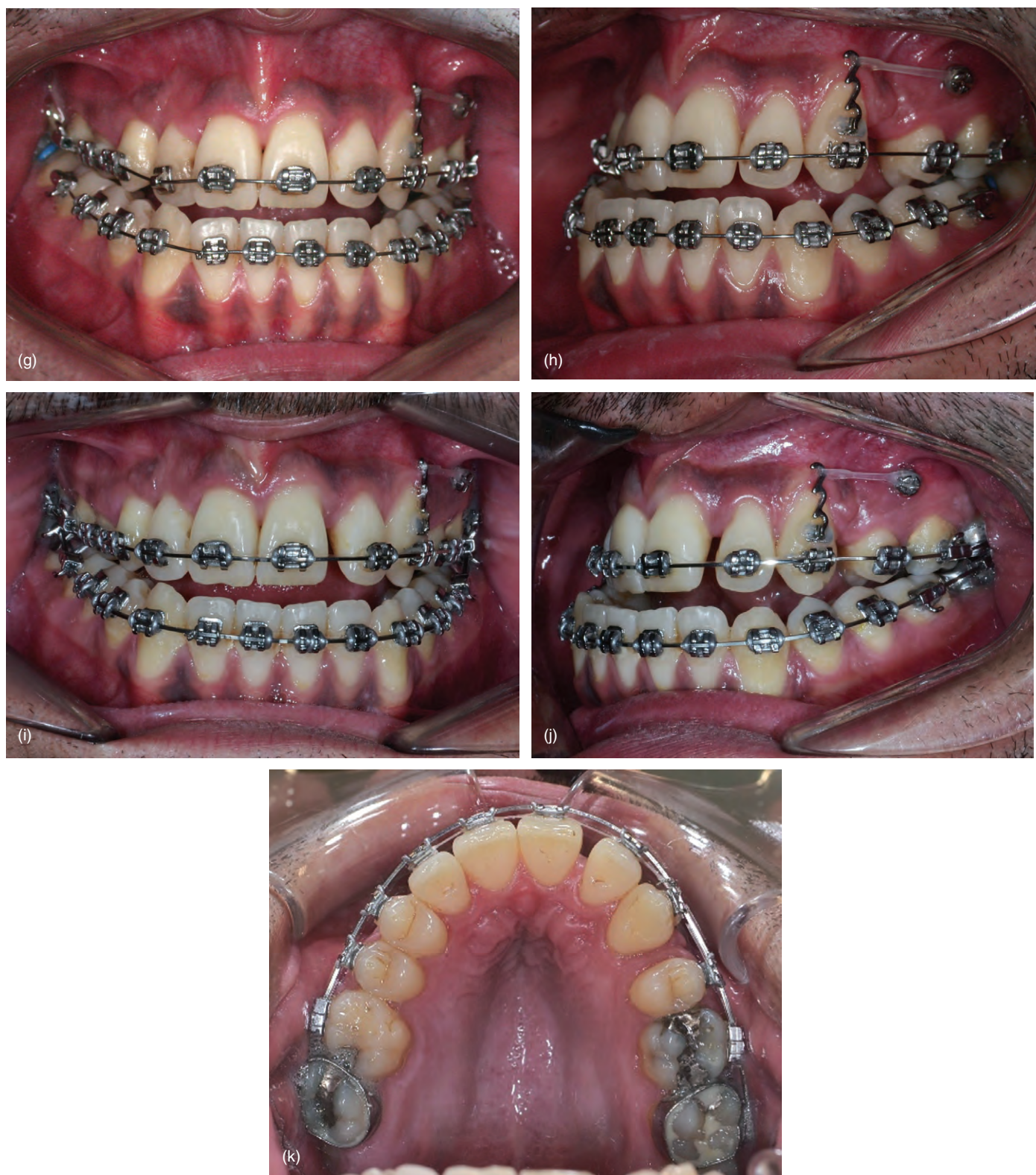


Figure 10.1 *Continued*

plane may predominate. Therefore the diagnostic process should determine both the extent and nature of the transverse and vertical contributions to the whole asymmetry. In particular, is the asymmetry panfacial or localised, dental or skeletal, and is a functional mandibular displacement present? A frontal poster-anterior cephalometric view or CBCT scan may be useful.

- The incisor (overjet, overbite) and canine relationships.
- The dental centrelines relative to the facial midline and (the lower one) to the mandibular midline.

Biomechanical principles

- Determine the ideal traction vector prior to mini-implant insertion. For example, if there is sufficient height of attached gingiva then the mini-implant may be sited at a relatively apical ('high' vertical) level. This provides the option of supplementary vertical intrusive traction, although a powerarm may be required to prevent unwanted vertical side-effects due to an oblique vector of antero-posterior traction. Conversely, if there is only a narrow band of attached gingiva then the mini-implant is limited to a coronal insertion level, resulting in closer proximity to the archwire plane and a relatively horizontal line of traction, but little scope for intrusive effects.
- Indirect (mid-palate) anchorage of a Nance palatal button involves force application from the fixed appliance molar hook. This means that the biomechanical effects are similar to conventional straight wire treatment.

- Transverse centreline correction involves either en masse incisor movements on a rigid (0.019×0.025) steel archwire, or the use of canine powerarm to enable movements on 'lighter' (e.g. 0.018) archwires (Fig. 10.1).

Clinical tips and technicalities

- Growing patients with reduced maxillary bone support (due to low density/thickness of the cortical plate) may be treated with indirect anchorage since the mid-palate cortex provides adequate stability in adolescents.

Mid-treatment problems and solutions

- Vertical side-effects such as a lateral openbite and excessive incisor retroclination:
 - Avoid the application of traction with a flexible archwire in situ or when a working steel archwire (e.g. 0.019×0.025) hasn't fully levelled the arch.
 - Add a unilateral curve to the working archwire on the traction side, i.e. a curve of Spee to a maxillary archwire and a reverse curve to a mandibular one.
 - Accept the openbite side-effect until anchorage is no longer required, then remove the mini-implant, bond the second molar in the affected quadrant, and use a flexible archwire to level the arch.
 - Vertical settling elastics may also be added although most lateral openbites readily settle once traction has ceased and the archwire changes are expressed.

Clinical steps for centreline correction

Pre-insertion

1. Increase the interproximal space available at the insertion site by bonding the attachments on the teeth at altered tips, e.g. for an insertion distal to the second premolar add mesial tip to its bracket, causing the root to move mesially during alignment.
2. If canine retraction is indicated prior to centreline correction, then align most of the arch (except for substantially displaced incisors) to prepare for a 0.018 steel working archwire and add a powerarm to the canine. Otherwise, for en masse incisor movement, align and level the whole arch to be ready to accommodate a 0.019×0.025 steel archwire. A powerarm can then be crimped to this archwire.
3. If desired, fabricate a stent by taking an impression of the arch one to two weeks pre-insertion. Avoid waxing out brackets and the buccal sulcus near the insertion site and record the clinical level of the mucogingival junction (to transfer to the working model).

Mini-implant selection

4. Maxilla: use a narrow long body, short neck mini-implant (e.g. 1.5mm diameter, 9mm length, short neck Infinitas version).
5. Mandible: use a narrow, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 6 or 9mm length, short neck version). The length selection largely depends on the height of attached gingiva and alveolar width at the insertion site, e.g. a 9mm length may be preferable where a limitation in one or both of these factors indicates the need for an oblique insertion angle.

Insertion

6. Identify the ideal buccal alveolar insertion point through attached gingiva (which does not require a soft tissue punch step).
7. Superficial anaesthesia of the insertion site.
8. Determine the angles of insertion. All mini-implants are inserted into the interproximal space and are perpendicular to the surface in the horizontal plane. Maxillary and posterior mandibular mini-implants may be inserted at either 90° (perpendicular to the surface) or angled obliquely by up to 30°, by inclining the screwdriver in an apical direction. Anterior mandibular insertions are inclined at 80–90° to the surface because of limitations due to the sloping shape of the alveolus.
9. Manual insertion is recommended where there is sufficient physical access (e.g. ease of stretching the cheek and buccal sulcus). Otherwise contra-angle handpiece insertion may be performed, but with resultant loss of full tactile control.
10. A cortical bone punch is recommended as the first step for posterior mandibular sites (except in young teenage patients with less dense cortex).
11. Complete the insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible. This is best performed gradually and with intermittent release of the screwdriver during the final turns, so that over-insertion is avoided.
12. Percuss the adjacent teeth to gauge root proximity and take an intra-oral radiograph if a problem is suspected.

Post-insertion

13. For initial canine retraction apply traction directly from the mini-implant head to the canine bracket/powerarm (Fig. 10.1).
14. For en masse labial retraction crimp a powerarm to the archwire mesial to the canine bracket. If necessary, adjust the level of traction on the powerarm to create a horizontal line of traction (parallel to the occlusal plane).
15. Immediately load the mini-implant with *light* traction for the first five to six weeks, e.g. a lightly stretched powerchain. Subsequently apply normal levels of traction using a NiTi closing spring or elastomeric.
16. Discontinue the traction and possibly explant the mini-implant once the anchorage requirements have been met, e.g. Class I canines and centred incisors.
17. If a lateral openbite has developed then (after explantation) bond the ipsilateral upper second molar and level the arch using a flexible NiTi archwire. Vertical or box elastics may also be used to settle the buccal occlusion.

CENTRELINE CORRECTION EXAMPLE (Fig. 10.2)

- This 27 year old female presented with a Class II division 2 malocclusion on a mild skeletal II base (Figs 10.2a–d). She had transverse skeletal asymmetry with the chin point displaced to the left side (without a functional displacement) and a subtle degree of vertical asymmetry (occlusal cant slightly higher on the left side). The upper incisor–lip relationship was aesthetically satisfactory. The upper right canine and the first premolars from the other three quadrants were absent. The upper and lower dental centrelines were displaced to the right and left sides, respectively, and the buccal segments exhibited similar asymmetry, including a $\frac{3}{4}$ unit Class II relationship of the left canines.
- Both arches were initially levelled and aligned. The left Class II canine relationship, deep overbite and lower centreline problems were additionally corrected by the use of pushcoil to re-open the lower left first premolar space.
- Asymmetrical anchorage was reinforced using 6 and 9mm length mini-implants inserted mesial to the lower left canine and upper left first molar, respectively (Figs 10.2e–g). Direct traction was applied to pull the maxillary incisors towards the left, whilst indirect anchorage was utilised in the mandibular arch, since the insertion site was anterior to the canine. This involved a 0.019×0.025 steel auxiliary wire and a cross-tube connecting the mini-implant and the main archwire. Elastomeric traction was used to protract the lower left molars.
- The patient declined to correct the vertical asymmetry, so the mini-implants were removed once the left molar relationship had been over-corrected so that finishing alignment could be performed (Figs 10.2h–j). This was followed by asymmetrical traction, predominantly Class III elastics on the right side, although a small residual centreline discrepancy was accepted due to tooth size discrepancies (Figs 10.2k–n).



Figure 10.2 (a–d) Pre-treatment views showing this Class II malocclusion with absence of the upper right canine and first premolars in the other three quadrants, asymmetric buccal segment relationships and centreline discrepancies. (e–g) The lower left premolar space has re-opened during alignment and lower centreline correction. Upper posterior and lower anterior mini-implants are being used for upper centreline correction and lower molar protraction, respectively. Indirect anchorage is used to provide a horizontal vector of traction from a 0.019×0.025 steel auxiliary wire (connected vertically between the archwire and mini-implant head). (h–j) Finishing alignment and then asymmetric settling elastics are used after removal of the mini-implants. (k–n) Debond views.



Figure 10.2 *Continued*



Figure 10.2 *Continued*

UNILATERAL INTRUSION (VERTICAL ASYMMETRY CORRECTION)

Clinical objective

- Asymmetrical intrusion of the maxillary or mandibular teeth to level the occlusal plane and smile line.

Treatment options

- Unilateral mini-implant intrusion, except where contra-indicated in patients with a Class III skeletal pattern or reduced lower anterior face height.
- Conventional anchorage involving asymmetric headgear.
- Hybrid functional (orthopaedic) appliance, but with a reliance on asymmetric extrusive changes.
- Asymmetrical orthognathic surgical movements.

Relevant clinical details

- Unilateral or even bilateral asymmetric intrusion is ideal for those patients with a predominantly vertical asymmetry accompanied by an average or increased maxillo-mandibular angle and Class II features. Full bilateral treatment involves intrusion of teeth in diagonally opposing quadrants (e.g. upper right and lower left quadrants).
- The incisor relationship (overjet, overbite).
- The maxillary and mandibular occlusal planes and whether an occlusal cant is present.
- The upper incisors' vertical display (on both passive and smiling exposure) and the smile arc.

Biomechanical principles

- Simultaneous buccal and palatal mini-implant anchorage in the maxillary arch ensures true vertical movements within a quadrant, and avoids transverse side-effects or the need for a modified TPA (which allows differential molar movements). Since lingual insertion sites have a low success rate then mandibular intrusion utilises buccal mini-implants only and requires transverse control using a full fixed appliance.
- The mini-implants should be vertically positioned in relatively apical sites, such that the buccal one is

close to, or at the, muco-gingival junction. This provides an adequate distance for effective traction, especially as the adjacent teeth intrude towards the implant head.

- Unilateral intrusion forces should be applied with a rigid (0.019 × 0.025) steel archwire in place.

Simultaneous buccal and palatal mini-implant anchorage in the maxillary arch ensures true vertical movements within a quadrant, and avoids transverse side-effects.

Clinical tips and technicalities

- Consider removal of erupted third molars (prior to orthodontics) in the quadrant(s) where molar intrusion is required.
- Bond the second molars, where erupted, in the quadrant requiring intrusion.
- In vertical correction cases, monitor the occlusal plane by measuring the overbite involving the incisors and canine teeth, and their vertical display relative to the lip level. Also, monitor lateral openbites and hence the need for extrusion of the opposing teeth or additional intrusion in the diagonally opposite quadrant.

Mid-treatment problems and solutions

- Vertical side-effects such as a rollercoaster buckling of the arch and lateral openbite:
 - Ensure that the second molars are bonded when fully erupted.
 - Avoid the application of traction with a flexible archwire in situ.
 - Vertical settling elastics may be used to close a lateral openbite by extrusion of the opposing arch. The elastics may be connected either to the mini-implant anchored teeth or directly to the mini-implant head. The latter avoids any risk of extrusive relapse of the intruded teeth.

Clinical steps for unilateral intrusion*Pre-insertion*

1. Determine the insertion sites, e.g. a buccal one between the maxillary premolars and a palatal one between the molars, prior to bond-up. The insertion of both buccal and palatal mini-implants in the same interproximal space should be avoided. Instead, the palatal mini-implant should be in a more distal site than the buccal one, since more molar interproximal space is available on the palatal aspect.
2. This pre-planning enables active divergence of adjacent premolar roots to be undertaken, to allow for both ease of buccal mini-implant insertion and subsequent vertical tooth movements. For example, diverge the premolar roots by adding mesial and distal tip to the first and second premolar brackets, respectively. Remember that these tip alterations can readily be corrected at the treatment finishing stage.
3. Align and level the whole arch or initially only the segment(s) due for intrusion. This depends on whether there is a vertical discrepancy between the anterior and posterior teeth, where a large step favours segmental mechanics; whilst the risk of occlusal interferences from displaced anterior teeth necessitates full arch alignment.
4. Expand the maxillary arch where necessary to facilitate arch coordination (following subsequent mandibular autorotation).
5. Include bonded tubes on the second molars, if fully erupted, early in treatment. If the second molars are not fully erupted then do not bond them during initial alignment. Remember to avoid molar bands in order to facilitate effective gingival hygiene at the posterior limit of the dental arch where a reduction in crown height may occur and toothbrush access is most limited.
6. Once a 0.019×0.025 NiTi archwire has been inserted then book two clinical appointments if a stent is to be fabricated (which is especially valuable for palatal site guidance).
7. At the preparatory appointment take an alginate impression for a guidance stent if desired. Palatal stents do not require an accurate buccal alveolar impression, but remember not to wax out the brackets adjacent to a buccal insertion site.
8. Take periapical radiographs or a sectional CBCT to evaluate the positions of the roots adjacent to the insertion sites, either at the preparatory stage (when stent usage is planned) or at the start of the insertion appointment.

Mini-implant selection

9. Maxilla: use 1.5mm diameter, 9mm length mini-implants (for Infinitas), with short and long necks on the buccal and palatal alveolar sides, respectively. However, if the palatal tissues are particularly thick or the patient is still undergoing considerable somatic growth, then a 2mm diameter version may be indicated to give maximum primary stability without relying on full depth intra-bony insertion.
10. Mandible: body length selection depends on the anticipated cortical depth and density such that a long length (9mm) version is preferable for adolescent patients, where the cortical bone is immature. An Infinitas 1.5mm diameter, 6mm length, short neck version may be used in an adult.

Insertion

11. Superficial anaesthesia of the insertion sites, e.g. blanch the overlying mucosal area with a local anaesthetic injection, especially in the palatal site, although topical anaesthetic alone may be sufficient in the buccal site.
12. Fit the stent (where applicable).
13. Use a mucosal punch for palatal insertions. Temporarily remove any stent, after the surface has been marked with it in situ, so that the mucotome can be applied perpendicular to the surface, providing a clean cut of the tissue. If necessary, then remove the mucosal tissue with a mosquito forceps and/or Mitchell's trimmer.

14. In adults, use a cortical bone punch to perforate the relatively dense thick palatal and mandibular cortex.
15. Insert buccal and palatal maxillary, and buccal mandibular mini-implants, according to the treatment plan. Remember to use a speed-reducing (e.g. 128:1 ratio) contra-angle handpiece at less than 100 rpm for palatal sites.
16. The buccal insertion sites should be at or close to the muco-gingival junction and the vertical angle of insertion should be perpendicular to the bone. These details enable reliable attachment of the traction and a maximum range of intrusion movement.
17. Take an intra-oral radiograph if close root proximity is clinically suspected (due to pain sensation on percussion of an adjacent tooth).
18. Complete insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible.

Post-insertion

19. Insert a 0.019 × 0.025 steel archwire.
20. Bond attachments (buttons or cleats) to the palatal surfaces of the crowns adjacent to any palatal mini-implants.
21. Apply approximately 50 g (elastomeric chain) traction for the first four to six weeks. This utilises the palatal attachments and the simplest configuration is a 'V' one, where the traction component's ends are attached to the teeth and its mid-section engages the mini-implant head. On the buccal side, the traction may be applied directly to the adjacent brackets or around the archwire. Following the initial healing period, stronger (150–200 g) elastomeric or closing coil auxiliary traction should be used.
22. Monitor treatment progress by recording the following features at the start of intrusion and at subsequent appointments: overjet, AOB/overbite, canine relationship, the upper incisor display (at rest and on full smiling), occlusal cant and presence of any molar openbite.
23. Monitor the periodontal condition (probing depth) of the terminal molars.
24. Consider over-correction of the intrusion changes to allow for possible relapse and/or keep the mini-implants in situ until it is clear that further anchorage is not required.
25. Consider an initially intensive retention regimen, e.g. three months full-time wear of plastic retainers with whole arch occlusal coverage. These should prevent early molar extrusion after debond.

UNILATERAL INTRUSION EXAMPLE (Fig. 10.3)

- A 28 year old female presenting with a Class II division 2 malocclusion on a skeletal I base with an average MMPA (Figs 10.3a–c). She had predominantly vertical dentofacial asymmetry with the maxillary plane canted downwards on the left side and more gingival display on this side on full smiling (although she camouflaged this by habitually smiling by only a limited extent). All first premolars plus a lower incisor were absent, and unsuccessful surgical recontouring of the maxillary gingival margin had previously been performed.
- The maxillary arch was levelled and aligned to accommodate a 0.019 × 0.025 steel archwire (Figs 10.3d, e). A 1.5 diameter, 9mm length mini-implant was then inserted on both sides of the left maxillary alveolus: mesio-buccal and disto-palatal to the first molar (Figs 10.3f–h). Elastomeric traction was applied buccally to the upper left premolar bracket and molar tube, and palatally to buttons on the palatal surfaces of the molars.
- Both the malocclusion and smile aesthetics were improved by five months of intrusion prior to bonding the lower fixed appliance (Figs 10.3i–k). Notably there was more vertical clearance for the left molars, although it appeared that these may have undergone some compensatory eruption.
- After a further four months the maxillary and mandibular planes and smile line were level (Figs 10.3l–n). Intrusion was continued for some over-correction and any consequent left lateral openbite would be corrected by lower left molar elastic extrusion (given the originally deep overbite).



Figure 10.3 (a–c) Pre-treatment views where the patient's habitual smile camouflages her vertical maxillary cant and gingival level asymmetry. The Class II division 2 malocclusion is shown with absence of upper first premolars and a lower incisor. (d–h) Left-sided intrusion commences with a 0.019 × 0.025 steel archwire in situ. Elastomeric traction is applied to the brackets and palatal cleats from mini-implants sited buccal and mesial to the maxillary left first molar, and palatal and distal to this first molar. (i–k) the maxillary cant is levelling and the lower arch is being aligned, with relatively gingival bracket positions in the lower left quadrant to assist with vertical compensation and overbite reduction. (l–n) The occlusal and gingival planes are level with the smile line, and divergence of the archwires on the left side is becoming evident, providing scope for left vertical elastic traction (if needed).



Figure 10.3 *Continued*



Figure 10.3 *Continued*

TRANSVERSE CORRECTION OF ECTOPIC TEETH

Conventional alignment of an ectopic tooth, such as a maxillary canine, requires a stable base from which traction is applied to move the displaced tooth towards its alveolar position. This involves either a full fixed appliance or a partial one supported by trans-arch anchorage (typically a TPA). However, this may mean that the patient has a fixed appliance which is otherwise passive on many teeth for a protracted period of time. In addition, it may be difficult to achieve the optimum vector of traction and anchorage loss may cause unfavourable loading and movement of adjacent teeth, especially if they have reduced root or periodontal support. The alternative is to use a mini-implant to provide an anchorage point for either direct traction to the ectopic tooth, or to form an (indirect) anchorage unit.

Clinical objectives

- Anchorage reinforcement to facilitate alignment (at least of the crown) of an impacted, ectopic or ankylosed tooth, e.g. a palatally ectopic maxillary canine.

Treatment options

- Conventional anchorage involving a full fixed appliance, or a sectional appliance supported by a TPA.
- Direct mini-implant traction to the ectopic tooth.
- Indirect mini-implant anchorage, where either an anchor tooth or the archwire are stabilised.

Relevant clinical details

- The number and location of teeth to form a potential anchorage unit.
- The length and shape of the roots of teeth adjacent to the ectopic tooth, since these may be short due to microdontia and/or root resorption. A typical example of this is a microdont lateral incisor adjacent to an ectopic maxillary canine. Consequently, these adjacent teeth may be unable to tolerate the prolonged and relatively heavy force application associated with alignment of an ectopic tooth.

Biomechanical principles

- Determine the direction of tooth movement and hence the ideal traction vector prior to mini-implant insertion. For example, does the ectopic tooth need to be moved distally as well as laterally? This helps



Figure 10.4 Indirect stabilisation of a 0.019 × 0.025 steel archwire, using 0.019 × 0.025 vertical auxiliary wires, prior to surgical repositioning of the upper right central incisor dentoalveolar block.

to decide whether direct or indirect anchorage is appropriate.

- Direct traction is delivered using a traction auxiliary from the mini-implant to the tooth, or via a cantilever arm. The former may be used when there is both a stable insertion site and sufficient traction distance to allow for the tooth's movement towards the mini-implant. Alternatively, a cantilever arm may deliver traction from a more remote insertion site.
- Indirect anchorage may involve a rigid auxiliary wire bonded onto an anchor tooth. This enables traction to be applied from this anchor unit to the ectopic tooth, e.g. from a buccally anchored maxillary first premolar to a palatally ectopic canine. Alternatively, the working archwire (of a fixed appliance which is already in situ) may be stabilised using a combination of an auxiliary wire and cross-tube (Fig. 10.4).
- Insertion of an interproximal mini-implant may restrict the effective range of traction, e.g. mesial to the first premolar tooth may cause the ectopic canine to approximate the mini-implant, i.e. the mini-implant position would inhibit full canine alignment.

Determine the direction of tooth movement and hence the ideal traction vector prior to mini-implant insertion.

Clinical tips and technicalities

- A cantilever arm should be attached to either two mini-implants, or to a single mini-implant and an adjacent tooth. This linkage minimises the rotational destabilising side-effects on a single mini-implant.
- Consider mini-implant insertion when the ectopic tooth is being surgically exposed, provided that the insertion site doesn't interfere with the access flap. Otherwise, delay insertion until the traction is required.
- If a deciduous tooth is retained in the ideal insertion site then extract this and allow a minimum of two

months for alveolar bone healing. Even then, it is prudent to insert the mini-implant into inter-septal bone since the buccal cortex may be deficient in a deciduous tooth site.

Mid-treatment problems and solutions

- Close proximity of the ectopic tooth and mini-implant may render the traction ineffective. If so, the mini-implant should be removed and either replaced in a new location (which is favourable for the direction and distance of traction) or the treatment continued by conventional means.

Clinical steps for ectopic tooth alignment

Pre-insertion

1. For alveolar sites, check whether there is sufficient interproximal space at the mini-implant insertion site(s). If not, then choose an alternative site (and possibly different biomechanics) or increase the interproximal space by diverging the adjacent roots. This may be achieved with a sectional fixed appliance where the attachments are bonded on the adjacent teeth at altered tips, e.g. add mesial and distal tip to the first and second premolar brackets, respectively, when an inter-premolar insertion is required.
2. If desired, especially for palatal sites, prepare an insertion stent by taking an impression of the arch one to two weeks pre-insertion. Avoid waxing out brackets and the buccal sulcus near a buccal insertion site and record the clinical level of the mucogingival junction.

Mini-implant selection

3. Maxilla: use a narrow long body, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 9mm length, short neck version).
4. Mandible: use a narrow, short neck mini-implant (e.g. Infinitas 1.5mm diameter, 6 or 9mm length, short neck version). The length selection largely depends on the height of attached gingiva and alveolar width at the insertion site, e.g. a 9mm length may be preferable where a limitation in one or both of these factors indicates the need for an oblique insertion angle.

Insertion

5. Identify the ideal buccal or palatal insertion point, through attached gingiva (which doesn't require a soft tissue punch step for buccal sites).
6. Superficial anaesthesia of the insertion site.
7. Determine the angles of insertion. Mini-implants inserted into the interproximal space are generally perpendicular to the surface in the horizontal plane. Maxillary and posterior mandibular mini-implants may be inserted at either 90° (perpendicular to the surface) or angled obliquely by up to 30° to the vertical plane, by inclining the screwdriver in a slightly apical direction. Anterior mandibular insertions are inclined at 80–90° to the surface because of limitations due to the sloping shape of the alveolus.
8. Manual insertion is recommended where there is sufficient physical access (e.g. stretching of the cheek and buccal sulcus). Otherwise contra-angle handpiece insertion may be performed, but with resultant loss of full tactile control.
9. A cortical bone punch is recommended as the first step for posterior mandibular sites (except in young teenage patients with less dense cortex).

10. Complete the insertion to the point that the mini-implant neck is partially submerged but the head is fully accessible. This is best performed gradually and with intermittent release of the screwdriver during the final turns, so that over-insertion is avoided.
11. Percuss the adjacent teeth to gauge root proximity and take an intra-oral radiograph if close root proximity is suspected.

Post-insertion

12. For indirect anchorage, bond a 0.019×0.025 steel auxiliary wire from the mini-implant head, and connect it either to an anchor tooth's crown or to a cross-tube on the working archwire (Fig. 10.4).
13. For direct anchorage, connect the traction auxiliary between the mini-implant and the ectopic tooth.
14. Immediately load the mini-implant with *light* traction for the first five to six weeks, e.g. a lightly stretched powerchain. Subsequently apply normal levels of traction using a NiTi closing spring or elastomeric.
15. Discontinue the traction and explant the mini-implant once the anchorage requirements have been met or there is insufficient distance for continued effective traction.

CASE EXAMPLES**1. Ectopic tooth: example one (Fig. 10.5)**

- This 31 year old female presented with a Class II division 1 malocclusion on a Class I skeletal base with an ectopic upper right canine and retained deciduous canine (Figs 10.5a, b). She had a history of aggressive periodontal disease predominantly affecting the incisors and first molars, and requiring extraction of the upper left central incisor.
- Since it was ideal to limit the time and periodontal effects of fixed appliance treatment, initial movement of the ectopic canine involved elastomeric traction from a mini-implant inserted in the interseptal bone mesial to the first premolar (Figs 10.5c, d). This also enabled the patient to wear a vacuum-formed appliance containing two incisor pontics for aesthetic purposes (Fig. 10.5e).
- The mini-implant was explanted when the canine crown was close to the line of the arch and there was insufficient traction distance (Figs 10.5f, g). Conventional fixed appliance treatment was commenced and completed after full arch alignment and space reduction had been achieved (Fig. 10.5h).

2. Ectopic tooth: example two (Fig. 10.6)

- This 14 year old female presented with a Class II division 2 malocclusion on a Class I skeletal base with an absent upper left lateral incisor and adjacent ectopic canine (Figs 10.6a, b). Treatment was complicated by short root lengths of multiple teeth and the upper left first molar required endodontic treatment.
- Two (1.5mm diameter, 9mm length) mini-implants were inserted in the buccal aspect of the alveolus, adjacent to the upper left second premolar (Figs 10.6c, d). A cantilever arm was fabricated from a 0.019 × 0.025 steel wire, inserted into the paralleled slots of the mini-implant heads and secured there with composite.
- The lever arm was adjusted in situ during alignment of the canine, e.g. to extrude the tooth after crossbite correction (Figs 10.6 e, f).
- Once the canine crown was in the line of the arch it was feasible to complete treatment with a conventional fixed appliance treatment utilising light forces.

3. Ectopic tooth: example three (Fig. 10.7)

- This 15 year old boy presented with a Class I malocclusion on a Class I skeletal base with unerupted upper left premolar and molar teeth (Fig. 10.7a). Vertical traction was required to erupt these teeth, following their surgical exposure, but intra-arch traction was not feasible. Therefore, it was necessary to apply traction from the opposing mandibular arch.
- The lower left buccal teeth were aligned with a sectional fixed appliance ensuring that adequate interproximal space was created for insertion of two mini-implants mesial and distal to the lower left first premolar (Fig. 10.7b). Elastic intermaxillary traction was applied immediately to a connecting wire attached to the upper left premolar and molar teeth. Direct traction from the mini-implants, rather than from the fixed appliance, avoided extrusion of the lower posterior teeth.
- This direction of traction was modified during treatment to direct the maxillary teeth's eruption, for example to extrude the upper left first molar once its crown was sufficiently visible to be bonded (Figs 10.7c, d).



Figure 10.5 (a–b) Pre-treatment views of this Class II division 1 malocclusion where the upper left central incisor has a poor prognosis and the upper right canine is ectopic. (c–e) Vertical and lateral traction applied to the exposed canine crown from a mini-implant sited in the interseptal bone directly mesial to the right first premolar. A vacuum-formed appliance with two incisor pontics was worn at this time. (f, g) The mini-implant was removed when the canine crown approximated it, resulting in insufficient distance for traction. (h) Debond view.



Figure 10.5 *Continued*



Figure 10.6 (a–b) Pre-treatment views showing the absent upper left lateral incisor and recently exposed maxillary canine. (c, d) Cantilever traction to the canine crown using a 0.017 × 0.025 beta titanium wire from two mini-implants, which have been inserted in series. (e, f) Progressive lateral movement of the canine, by triple beak plier re-activation of the cantilever arm in situ.



Figure 10.7 (a) Pre-treatment panoramic radiograph showing the ectopic positions of the maxillary left premolar and molar teeth. (b) Left mandibular mini-implants for vertical traction to the exposed upper teeth, inserted following divergence of the adjacent roots with a sectional fixed appliance. (c, d) Traction continues in conjunction with flexible archwire alignment of these teeth.

Orthognathic Surgical Uses

Orthodontic mini-implants provide a variety of novel applications for adult patients undergoing orthognathic surgical correction of their dentoskeletal deformity. For instance, some patients have traditionally been viewed as unsuitable for orthognathic treatment because their dental status is suboptimal (due to insufficient teeth or periodontal support). This contraindicates intra-operative intermaxillary fixation (IMF) and post-operative elastic traction, or even pre- and post-surgical fixed appliance phases. However, it is now feasible to effectively manage such patients during the peri-operative period using mini-implants, either as an alternative to fixed appliance surgical hooks, whereby heavy elastic traction on vulnerable teeth is avoided, or in lieu of an orthodontic (labial) appliance altogether. In particular, mini-implants' relatively small body diameters and head sizes (Fig. 11.1a) mean that they pose less risk to dental roots and cause less trauma to the soft tissues, respectively, than conventional surgical intermaxillary (IMF) screws (Fig. 11.1b).^{1, 2, 3} Conventional pre- and post-surgical orthognathic treatment phases also benefit from the adjunctive use of mini-implants as described here.

Mini-implants can be used either as an alternative to fixed appliance surgical hooks, whereby heavy elastic traction on vulnerable teeth is avoided, or in lieu of an orthodontic (labial) appliance altogether.

Clinical objectives

The range of orthognathic treatment problems which may be overcome by the adjunctive use of mini-implants includes patients with:

- An insufficient number of teeth or periodontal tissue support to tolerate intermaxillary forces.
- Teeth at risk of extrusion due to short roots (during the use of intermaxillary traction).
- Treatment with lingual appliances, requiring a means of fixation on the labial side.
- A contradiction between incisor decompensation (involving proclination) and space closure.
- Absence of the lower first or second molars such that the mandibular third molar should ideally be protracted and preserved, rather than sacrificed as part of the mandibular surgery plan.
- Facial asymmetry which is primarily transverse, but where pre-surgical levelling of an associated occlusal cant will optimise the transverse and antero-posterior surgical correction.
- An incomplete or unsatisfactory surgical outcome, where further surgery is contraindicated or declined.

Treatment options

- Conventional surgical hooks for fixation and traction from a (labial) fixed appliance.
- Surgical fixation using archbars.
- Surgical anchorage using IMF screws (Fig. 11.1).
- Bimaxillary surgery, for asymmetry cases, where the occlusal plane is levelled by the maxillary osteotomy.
- Orthodontic mini-implants for intra-operative fixation and post-operative traction.

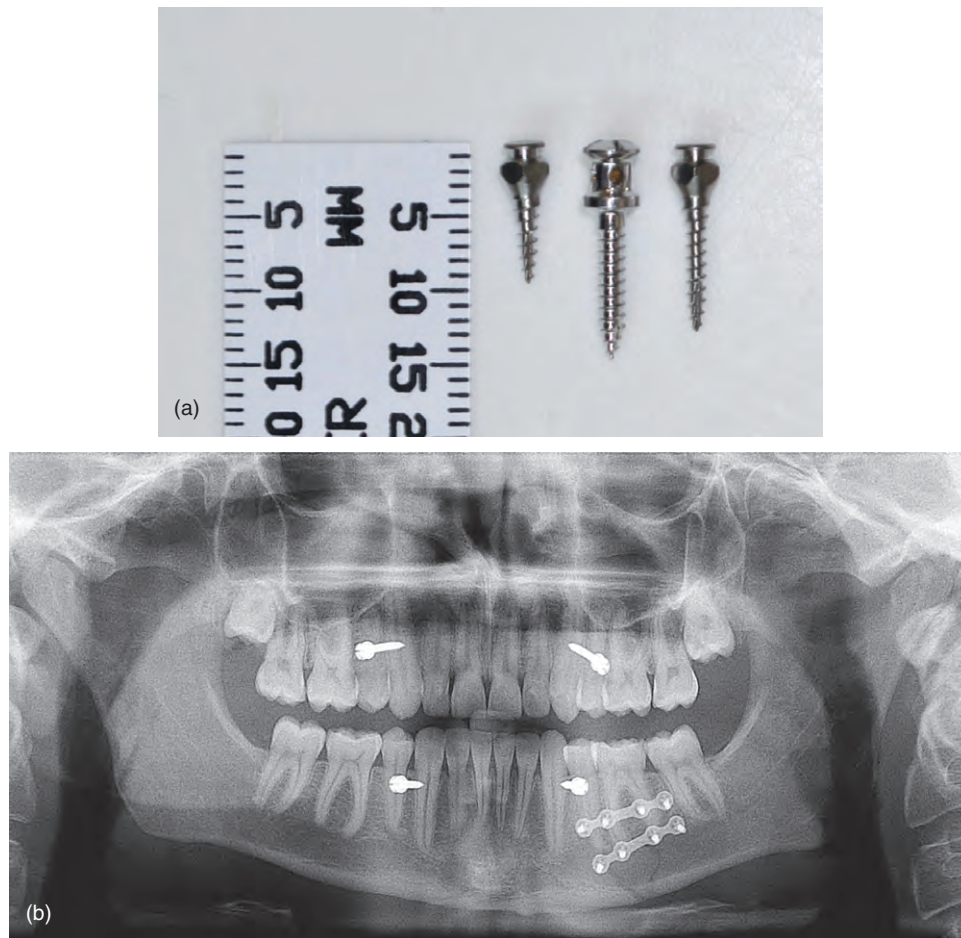


Figure 11.1 (a) Photograph of 6 (left) and 9 (right) mm length IMT mini-implant versions with an IMF screw in the centre. (b) Panoramic radiograph showing close root proximity and poor mesio-distal orientation of IMF screws in a trauma case.

Relevant clinical details

The stages during the orthognathic treatment pathway when mini-implants may be utilised are during the:

- Pre-surgical orthodontics.
- Orthognathic surgical episode, when IMF is required.
- Immediate post-operative phase, when intermaxillary traction is required.
- Post-surgical orthodontics.
- Long-term after surgical relapse has occurred.

The most relevant clinical details in determining mini-implant usage in this group of patients are the:

- Presence of an occlusal cant/vertical facial asymmetry.
- Periodontal status and root lengths of teeth since prolonged and/or heavy intermaxillary traction will have a deleterious effect on such teeth.

- Height of buccal/labial attached gingiva in areas where mini-implants are indicated.
- Root proximity of teeth adjacent to the planned insertion sites.

Biomechanical principles

- Ideally insert the mini-implants in sufficient numbers (typically five to six for full arch support), in both dentate and edentulous sites, where they will provide fixation points consistent with the planned lines of traction and occlusion.
- Elastics are less likely to be dislodged from a mini-implant which has been inserted in a horizontal direction (parallel to the occlusal plane) rather than at an oblique angle.
- Traction to 'settle' an unsatisfactory post-operative occlusion should be applied before maturation (solidification) of the osteotomy site callus.

Clinical tips and technicalities

- Remember that mini-implant insertion is a specific technique, which differs from that of both maxillofacial bone (screw) fixation and dental implantology. It is essential that whoever places the mini-implants must understand this fundamental issue, and pre-learn the relevant clinical instruments and steps. In particular, mini-implant insertion is a gentle technique using light forces, and one where the angles of insertion are carefully defined. These details can be critical since mini-implants typically remain in situ for months, relying on secondary stability, not just primary stability at the time of surgery. Surgical usage is further complicated by access problems since it can be surprisingly difficult to line up the correct path of insertion when the patient is supine and surgical drapes restrict lateral access. In such circumstances it is not unusual for fixation and surgical IMF screws to be inserted with their tips angled posteriorly. This can still be the case for posterior mini-implant insertions, as illustrated in Fig. 11.2 where mini-implants were inserted through the maxillary first molar furcations rather the adjacent interproximal spaces. All clinicians involved in surgical cases should be aware of this directional problem, and if in doubt then consider pre-surgical fabrication of a guidance stent.
- If the labial frenum is prominent then minimise patient discomfort, and soft tissue interference or overgrowth (over the mini-implant head), by either avoiding mini-implant insertion in the midline or performing a frenectomy.
- Horizontal angles of insertion (i.e. parallel to the occlusal plane) and full insertion of the mini-implants also help to minimise irritation of the lip/cheek soft tissues. Conversely, over-insertion makes it more likely that the intermaxillary wires/elastics may impinge on the adjacent gingival tissues.
- Consider pre-surgical root divergence to create interproximal space at the ideal mini-implant insertion sites. For example, limited fixed appliance alterations of the root alignment may be undertaken to facilitate mini-implant surgical usage. This may be particularly beneficial for sites such as the mandibular incisor region where the interproximal widths are typically narrow and the roots closely approximated.
- The anterior alveolar depth can be measured on a lateral cephalogram (Fig. 11.3). This will indicate whether the midline area provides sufficient depth for a long (e.g. 9 mm) body length mini-implant when it is inserted horizontally (parallel to the occlusal plane).
- Ideally use a mini-implant head with a rounded contour and low profile, e.g. the Infinitas IMT (Intermaxillary Traction) version with its mushroom-shaped head (Fig. 11.4). This ensures patient comfort when the mini-implants are inserted in



Figure 11.2 Panoramic radiograph showing mini-implants inserted in an orthognathic case, including two located in the maxillary first molar furcation areas.

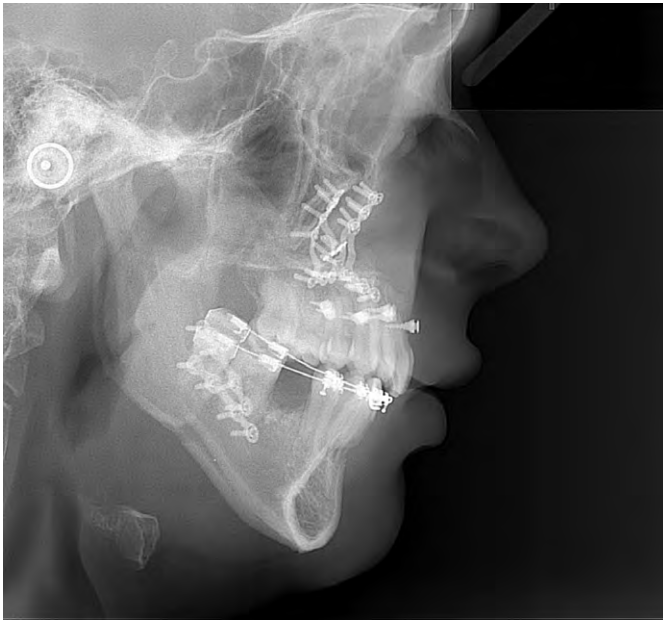


Figure 11.3 A lateral cephalogram showing the alveolar depth in the anterior maxillary and mandibular regions. The posteriorly directed angle of mini-implants inserted in theatre at the time of the osteotomy is also seen.

relatively remote sites and are more likely to rub against the cheeks and lips (without a nearby fixed appliance to buffer the soft tissue contact). The generous undercut of the Infinitas IMT mini-implant head also helps the patient to place and retain elastics used for traction.



Figure 11.4 Close-up views of the IMT mini-implants showing their head's large external undercut and mushroom-shaped top.

Remember that mini-implant insertion is a specific technique, which differs from that of both maxillofacial bone (screw) fixation and dental implantology.

Clinical steps*Pre-insertion*

1. Determine the insertion sites and number of mini-implants required.
2. Consider pre-surgical divergence of the roots of teeth adjacent to the insertion sites where the interproximal space is narrow and an alternative adjacent site not suitable. This may be the case particularly in the lower incisor area, where the limited height of attached gingiva also limits the option of avoiding the roots by using an apical insertion level. Divergence is achieved by bonding the brackets at altered tips, e.g. for insertion mesial to the canine root then add mesial tip to the lateral incisor bracket and distal tip to the canine one.
3. If the patient has vulnerable tooth roots then consider pre-surgical orthodontics for alignment purposes only, specifically to eliminate potential occlusal interferences at surgery. A rigid (e.g. 0.019 x 0.025 steel) orthodontic archwire, and surgical hooks, can then be avoided since mini-implants will be used for intermaxillary fixation and traction purposes.

Mini-implant selection

4. A narrow diameter mini-implant, e.g. 1.5mm, is appropriate for interproximal sites.
5. Select a mini-implant with a sufficiently long neck to reduce the risk of the intermaxillary wire/elastic catching on the gingival tissues.
6. If there is sufficient height of the attached gingiva then the insertion should be perpendicular to the surface. Consequently a long mini-implant body (e.g. 9mm length Infinitas version) should be used in posterior maxillary sites (distal to the canine) and also anteriorly, provided that there is sufficient depth of palatal alveolus to accommodate this. This can be verified on a lateral cephalogram (Fig. 11.3). A short body length (e.g. the 6mm Infinitas version) is appropriate for mandibular sites and in patients with a narrow anterior maxilla where there is a risk of perforating through to the palatal tissues.

Insertion

7. Superficial anaesthesia of the insertion sites, unless the insertions occur when the patient is under general anaesthesia.
8. Insert the mini-implants through attached gingiva, but close to or at the mucogingival junction in order to avoid the tooth roots, unless there is an abundance of interproximal space at the coronal level (negating the need for more apical insertion). A slight (10–30°) apical inclination is appropriate where the attached gingival height is limited, but surgeons should remember that the 'tent peg' principle (where screw insertions are coronally directed) is not appropriate for this form of fixation.
9. Use a mucotome for any insertions through loose mucosa.
10. Use a cortical punch to perforate dense cortex in the posterior mandible sites.
11. Insert the mini-implants on the buccal side of the alveolus and as horizontally (parallel to the occlusal plane) as possible.
12. Take an intra-oral radiograph (post-operatively) if close root proximity is suspected clinically.
13. Complete insertion to the point that the mini-implant neck is partially submerged yet the head is fully accessible.

Post-insertion

14. Apply IMF or elastic traction from the mini-implants to surgical hooks or other mini-implants in the opposing arch. Post-operative intermaxillary elastic traction is variable and dependent on the amount of mouth opening achievable. However, it is appropriate to use similar elastics and force levels to those utilised for conventional intermaxillary traction.
15. Keep the mini-implants in situ until it is clear that further anchorage is not required.

CASE EXAMPLES**1. Pre-surgical intrusion example (Fig. 11.5)**

- A 16 year old female with a Class III malocclusion featuring asymmetrical mandibular prognathism (chin displaced to the left side) and a mild occlusal cant (higher on the left side) (Figs 11.5a–f).
- An asymmetrical mandibular setback osteotomy was planned, and intrusion of the upper right buccal segment was indicated to facilitate optimal surgical positioning of the mandible.
- The maxillary arch was aligned and levelled then a buccal mini-implant (1.5mm diameter, 9mm length) was inserted mesial to the upper right first molar (Figs 11.5g, h). Elastomeric traction was applied to the adjacent second premolar bracket and first molar hook.
- This traction created a right lateral openbite such that the amount of intrusion had been over-corrected pre-operatively (Figs 11.5i–n).
- The mandible was surgically repositioned with the freedom to select an optimal vertical level on the right side, such that a right lateral openbite was still present one month post-operatively (Figs 11.5o–s).
- The patient's Class III malocclusion was corrected and her dental and facial asymmetries were improved without the need for a maxillary osteotomy. The right lateral openbite over-correction settled during the post-operative orthodontic phase, accepting a small residual centreline discrepancy (Figs 11.5t–y).

2. Intermaxillary fixation: example one (Fig. 11.6)

- A 15 year old female presented with a Class III malocclusion on a moderate skeletal III base due to maxillary hypoplasia (Figs 11.6a–c). The upper first premolars had been extracted during an earlier course of orthodontic treatment, and there was generalised shortness of the maxillary dental roots (Figs 11.6d–f). The mandibular arch was reasonably well aligned.
- The maxillary root problems severely restricted the scope for orthodontics in this arch to simple alignment (Figs 11.6g–k). A reasonable occlusion could be achieved without further mandibular arch orthodontics.
- A maxillary osteotomy was undertaken four months into treatment, with IMF achieved by the use of three maxillary and seven mandibular mini-implants (Figs 11.6l–o). An upper labial frenectomy was also performed.
- The mandibular mini-implants were sited apical to the MGJ, in loose mucosa and subsequently underwent tissue overgrowth (Fig. 11.6p). They were not required for post-operative traction and were easily removed after the soft tissues were eased off their heads, under local anaesthesia (Fig. 11.6q).
- The lower fixed appliance was debonded eight months post-operatively, accepting dental centreline discrepancies because of the limited orthodontic feasibility (Figs 11.6r–u).

3. Intermaxillary fixation: example two (Fig. 11.7)

- A 32 year old female presented with a Class III malocclusion and AOB. She had a moderate skeletal III base due to maxillary hypoplasia, and an increased mandibular plane angle (Figs 11.7a–e). She had been prepared for surgery previously, but this was postponed due to pregnancy and the fixed appliances removed because of severe (pre-existing) shortness of multiple tooth roots.
- A reasonable occlusion could be achieved without further active orthodontics, so the maxillary osteotomy was undertaken with the aid of ten upper and lower mini-implants for IMF (Figs 11.7f, g). An upper labial frenectomy was also performed.
- The mini-implants were not required for post-operative traction and were easily removed without local anaesthesia (Figs 11.6h–l).

4. Intermaxillary fixation and traction example (Fig. 11.8)

- A 19 year old female presented with a Class III malocclusion on a moderate skeletal III base due to mandibular prognathism (Figs 11.8a–d). The upper first premolars had been extracted during an earlier course of upper arch treatment, and there was generalised shortness of the maxillary dental roots, especially the incisors.

- The maxillary root problems severely restricted the scope for orthodontics in this arch. A reasonable occlusion could be achieved with mandibular arch alignment and decompensation only, so this was achieved with seven months of fixed appliance treatment (Figs 11.8e–i).
- A mandibular setback osteotomy was performed, with IMF from the lower fixed appliance to five maxillary mini-implants. These had been inserted using a single stent (Figs 11.6j, k) and a Class I occlusion was achieved.
- By two weeks after surgery the occlusion had altered with premature contact on the incisors and displacement of the lower centreline to the right side (Figs 11.8l–n). Post-operative traction was then applied, using normal intermaxillary elastics, in left Class III and an anterior cross-elastic configuration (Figs 11.8o, p). The occlusion had improved substantially after four weeks of traction (Figs 11.8q, r).
- The lower fixed appliance was debonded one month later, accepting minor occlusal and centreline discrepancies because of the limited orthodontic feasibility (Figs 11.8s–w).

5. Post-operative relapse and traction example (Fig. 11.9)

- A 38 year old female presented with a Class III malocclusion on a moderate skeletal III base, with asymmetrical mandibular prognathism (Figs 11.9a–d). The upper right canine and upper left first molar teeth were absent, and three of the upper incisors had root fillings and short root lengths.
- The arches were aligned and decompensated with fixed appliance treatment (Fig. 11.9e).
- An asymmetric mandibular setback osteotomy was performed, but an unfavourable bone split and osteotomy site infection on the left side resulted in a collapse of the left vertical mandibular height (Figs 11.9f, g). This manifested as premature contact of the left molars and complete anterior and right lateral openbites, and the lower incisors were also displaced anteriorly and to the right side.
- It was decided to use post-operative traction to mould the mandibular callus within the following two month period, rather than performing further surgery. Given the compromised nature of the upper incisor roots, five Infinitas mini-implants were inserted in the maxilla, and elastic traction applied from these to the lower fixed appliance. This initially involved left Class III and anterior 'bite closing' elastics (Figs 11.9h–j).
- A right sided Class III triangular elastic was added once a positive OJ and OB were achieved (Figs 11.9k–m). Bilateral traction continued a Class I occlusion had been achieved (Fig. 11.9n).
- The fixed appliances were debonded several months later, accepting minor occlusal and centreline discrepancies because of the limitations of orthodontic camouflage in this case (Figs 11.9o–s).



Figure 11.5 (a–f) Pre-treatment views of the Class III dentofacial features and mandibular asymmetry: the chin and lower centreline are displaced to the left and the occlusal plane is higher on the left side. ((b and e) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (g, h) A right lateral openbite beginning to develop with right maxillary intrusion, using a mini-implant sited buccal and mesial to the first molar. (i–n) A large lateral openbite has developed pre-operatively, eliminating potential occlusal interferences when the mandible is surgically repositioned. (o–t) Post-operatively the Class III and asymmetry problems have been corrected, and the mini-implant traction stopped. ((p and r) Copyright The Royal College of Surgeons of England. Reproduced with permission.) (u–w) Debond facial views and the occlusion (x, y) 18 months after debond.



Figure 11.5 *Continued*



Figure 11.5 *Continued*

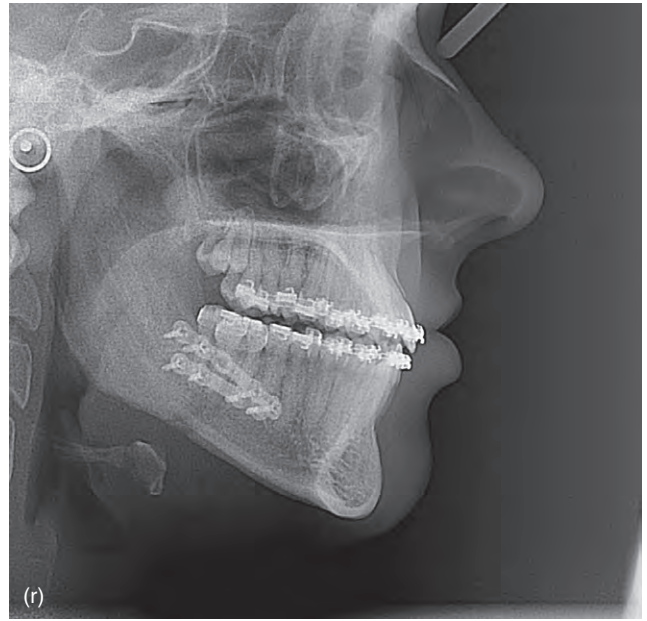


Figure 11.5 *Continued*



Figure 11.5 *Continued*



Figure 11.6 (a–f) Pre-treatment views showing the combination of Class III and multiple short maxillary root problems. The upper first premolars are also absent. (g–k) Pre-operative views following limited alignment and decompensation of the maxillary arch. No surgical hooks have been placed in the upper labial segment because of the short incisor roots. (l, m) Three upper and seven lower mini-implants inserted (free-hand) intra-operatively and used for wire IMF. (n, o) Post-operative radiographs showing several of the mini-implants close to the roots of teeth and the projection of the anterior ones. (p, q) Mucosal overgrowth of several lower mini-implants, sited at the MGJ, resolved by easing the tissue off these heads then explantation, under local anaesthesia. (r–u) Debond views.



Figure 11.6 *Continued*

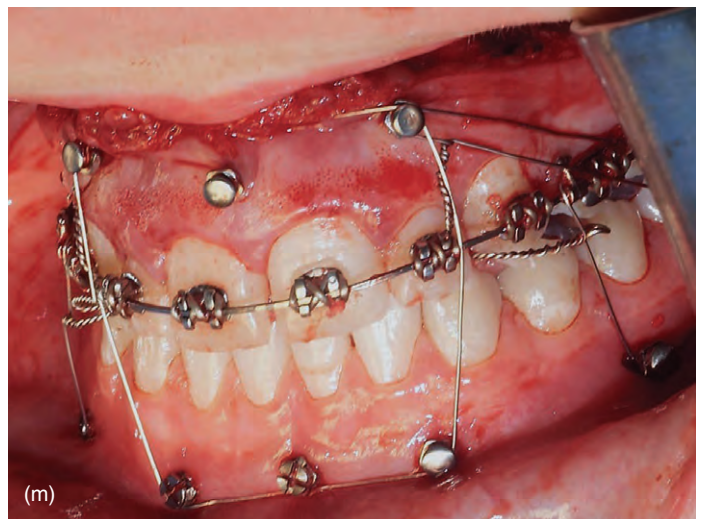
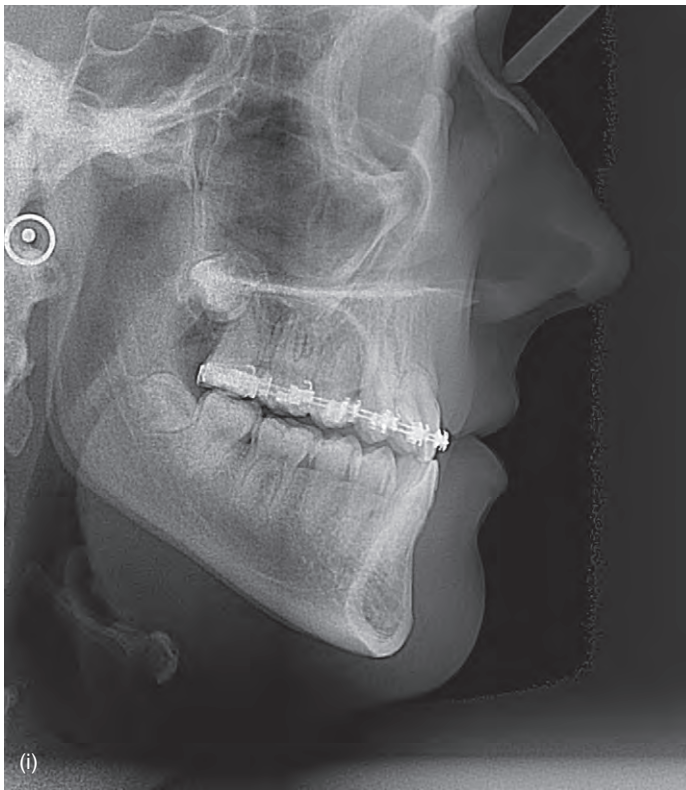


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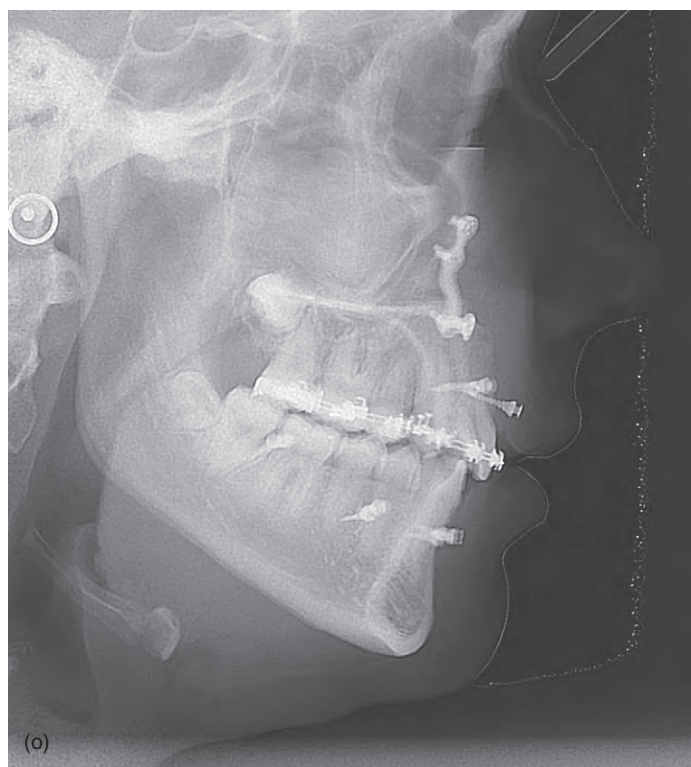
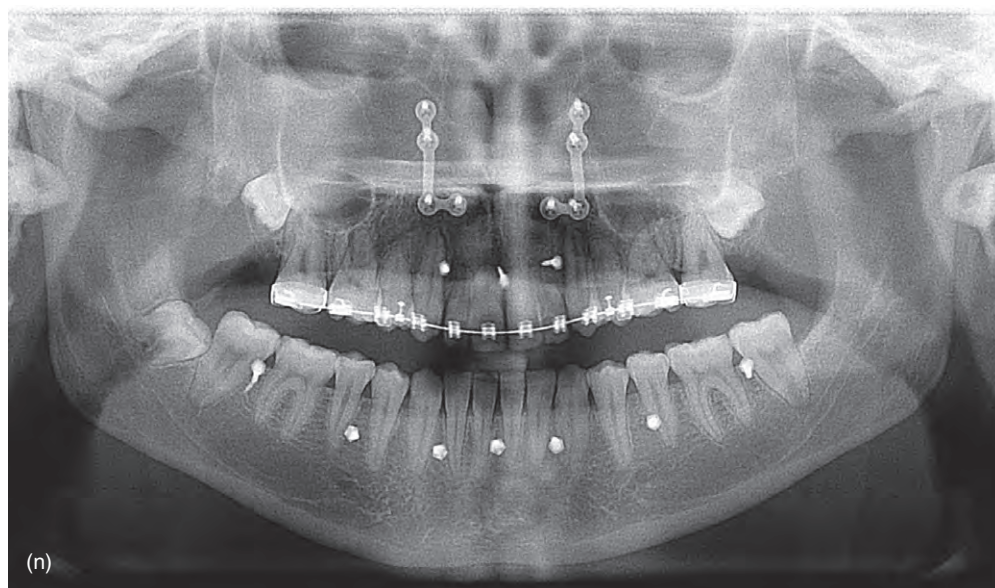


Figure 11.6 *Continued*



Figure 11.6 *Continued*



Figure 11.7 (a–e) Pre-surgical views of the Class III, hypodontia and microdontia problems. (f–h) The ten upper and lower mini-implants inserted at surgery and used for IMF. (i–l) Post-operative views with the mini-implants in situ in case of need for traction.

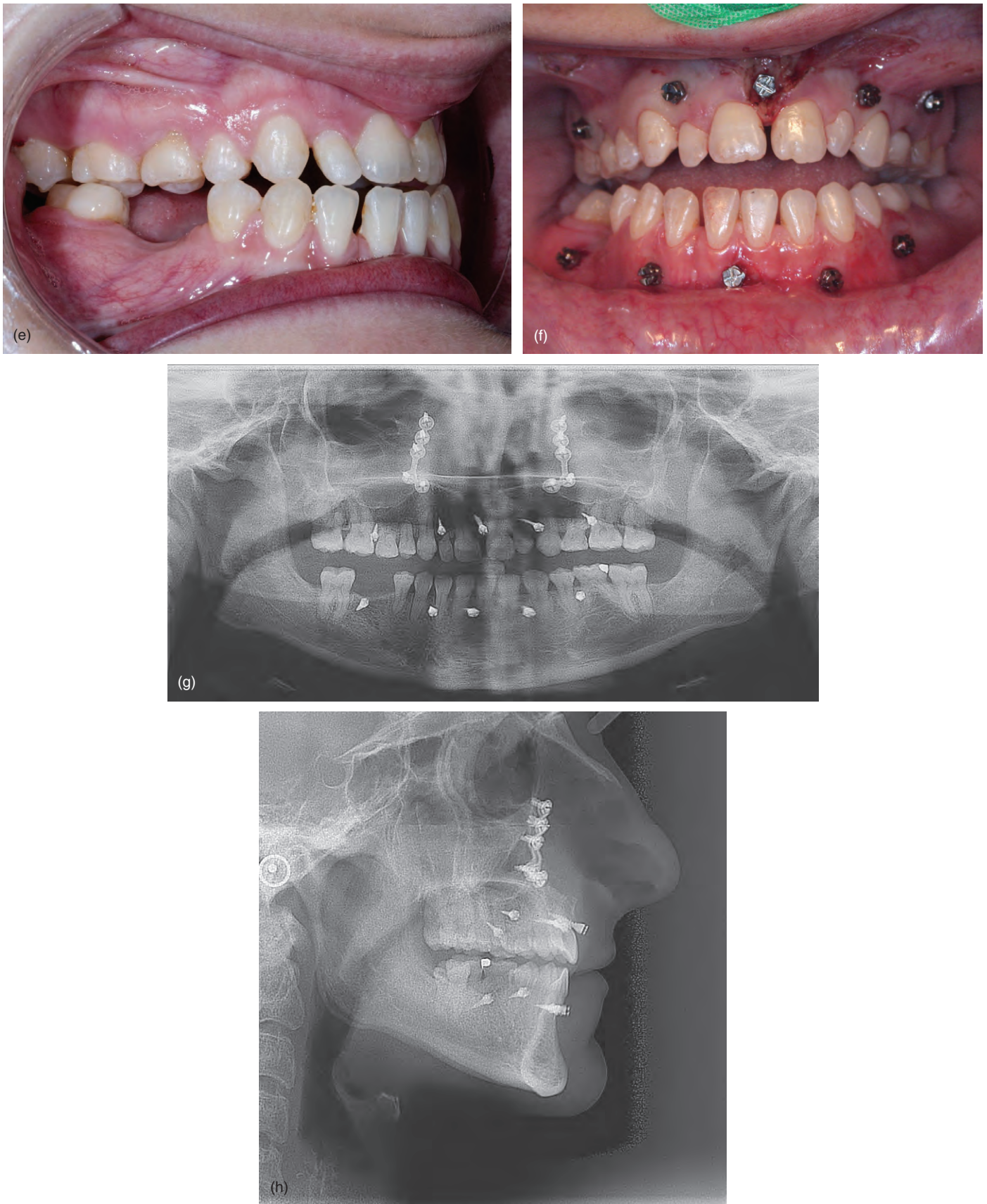


Figure 11.7 *Continued*



Figure 11.7 *Continued*



Figure 11.8 (a–d) Pre-treatment views of this Class III case with absent upper first premolars and traumatic incisor loading. (e–f) Pre-operative views after lower arch decompensation. (g) Insertion stent with five guidance cylinders in place intra-operatively. (h) Radiograph showing the maxillary mini-implants and mandibular fixation. (i–p) Two weeks after surgery the incisor relationship is Class III and the mandible is displaced to the right side. Left Class III elastic traction commences. (q, r) Class I occlusion being established after four weeks of traction. (s–w) Completion of traction and debond views, two months after surgery.

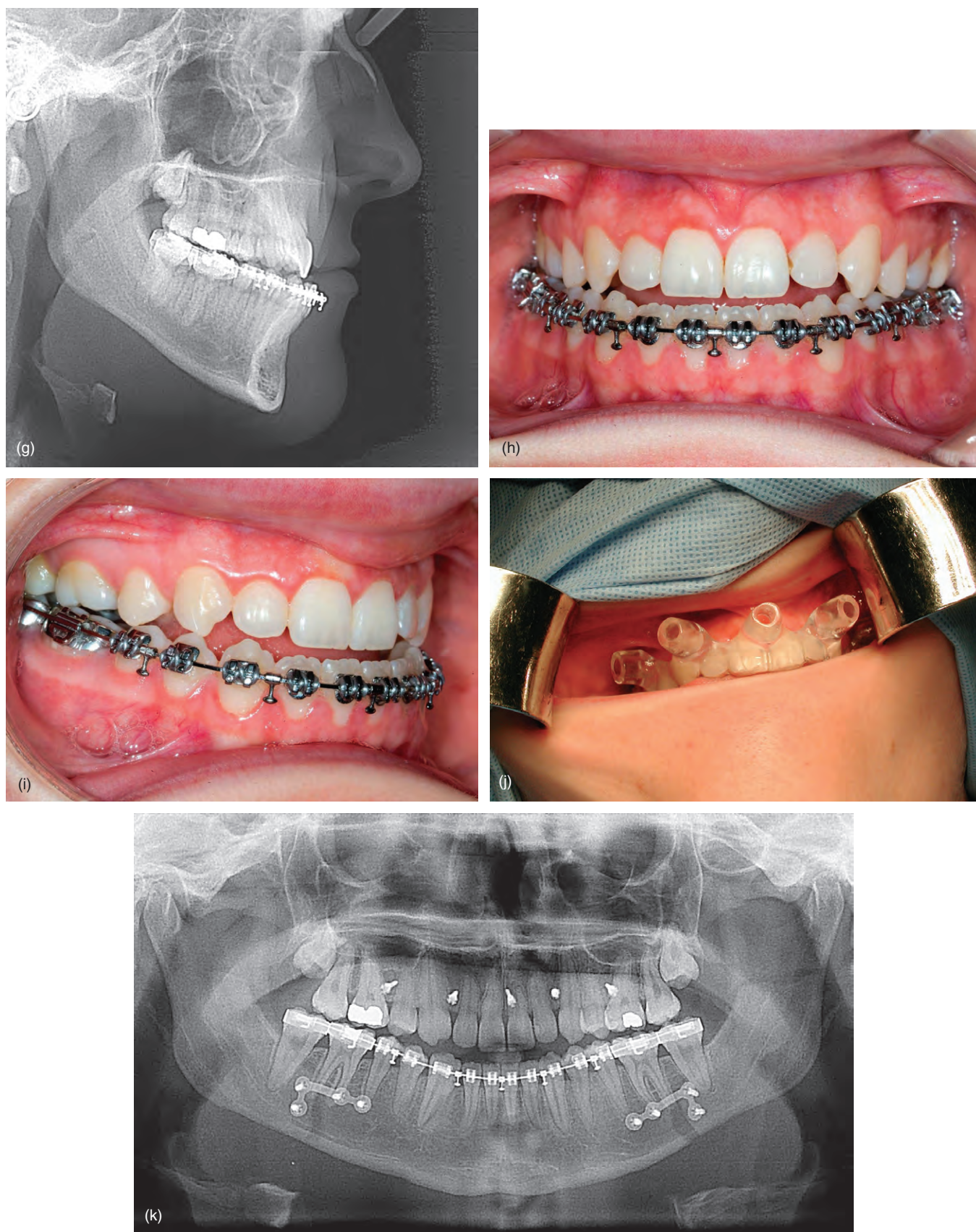


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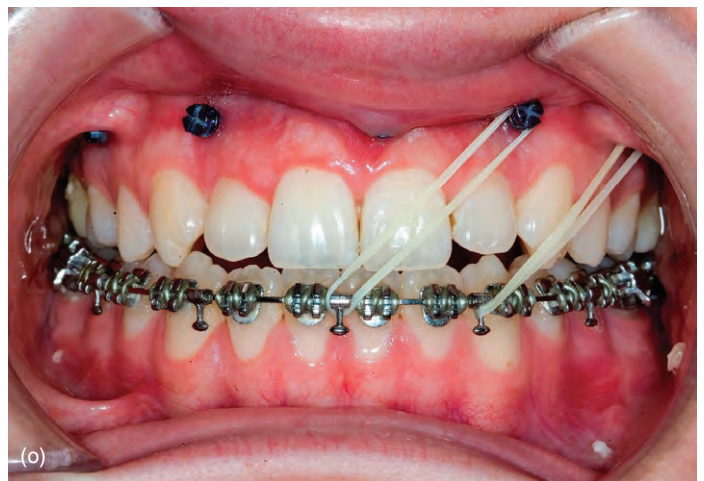
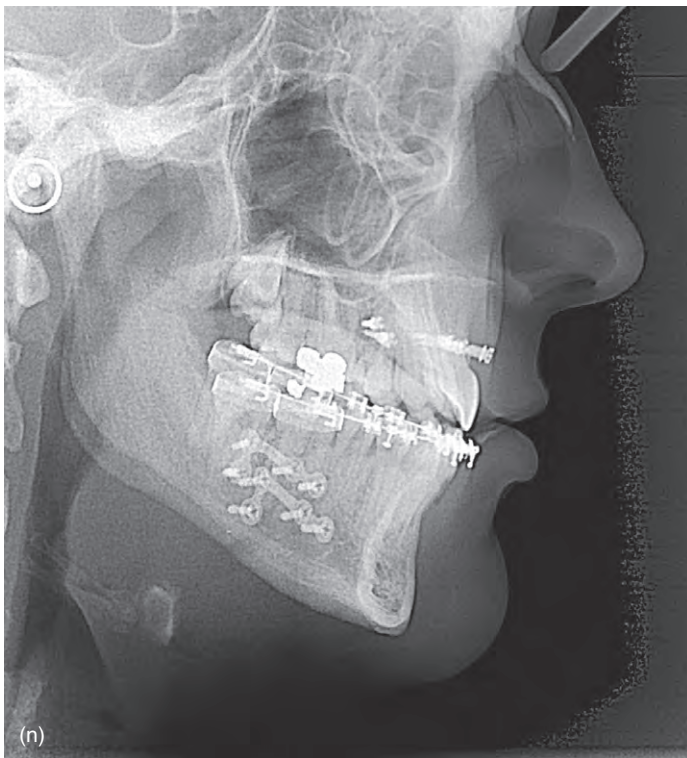


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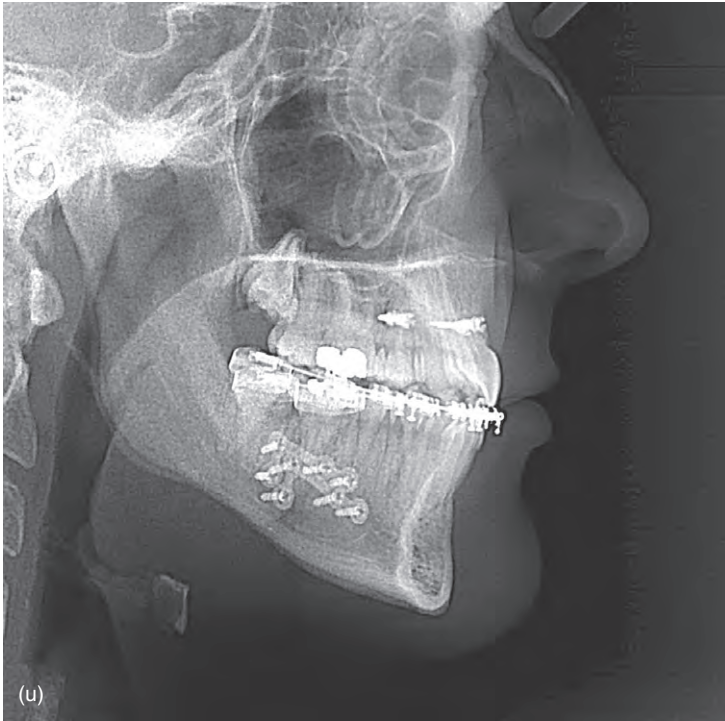


Figure 11.8 *Continued*



Figure 11.9 (a–e) Pre-treatment views showing the Class III malocclusion and mandibular asymmetry. (f, g) Radiographs showing the Class III and asymmetrical openbite after post-operative vertical collapse of the left mandibular ramus height. (h–j) Left Class III and anterior vertical traction applied to mould the mandibular callus. (k–n) Right Class III and vertical settling elastics are added to settle the mandible and occlusion into Class I positions. (o–s) Debond views.

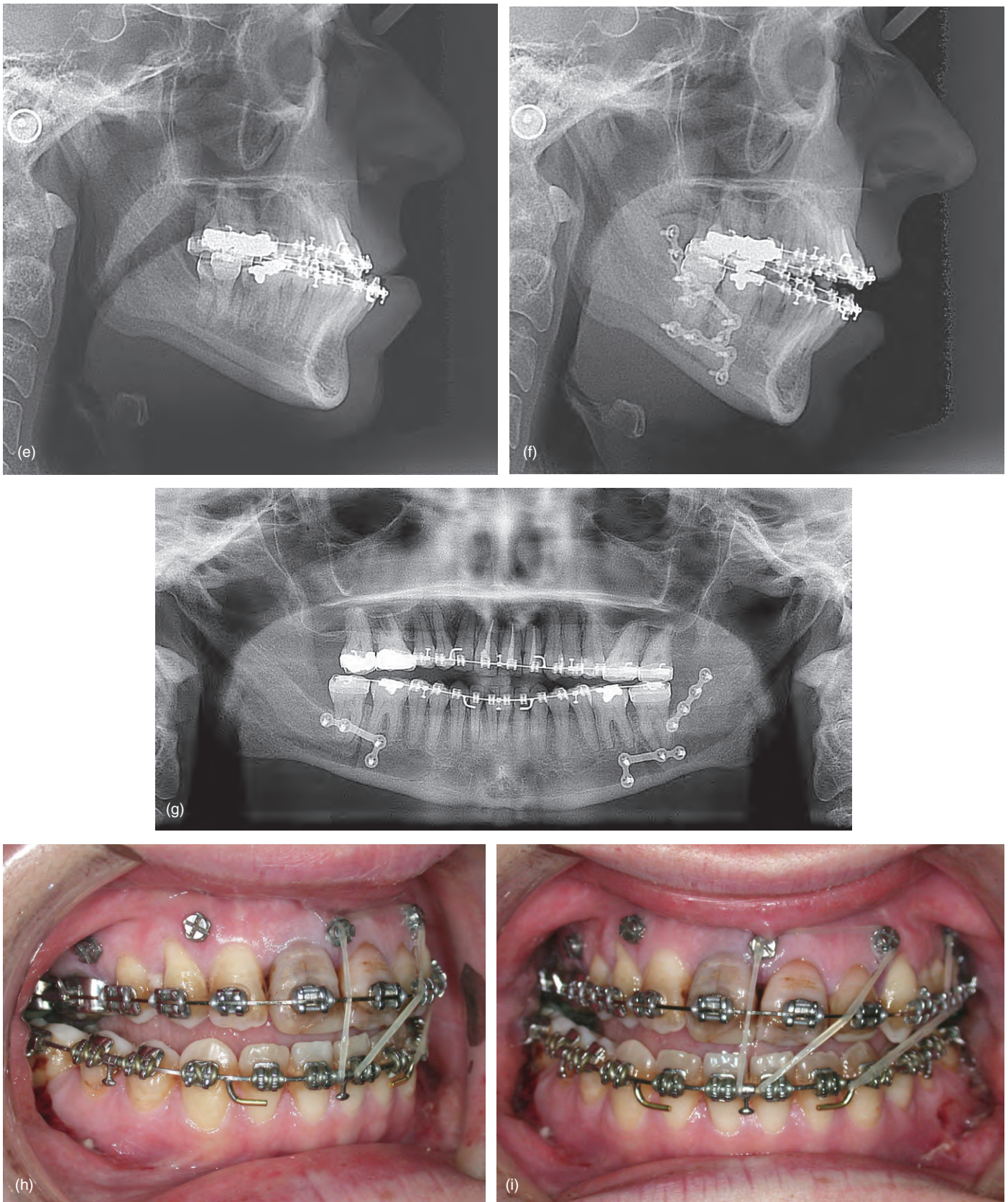


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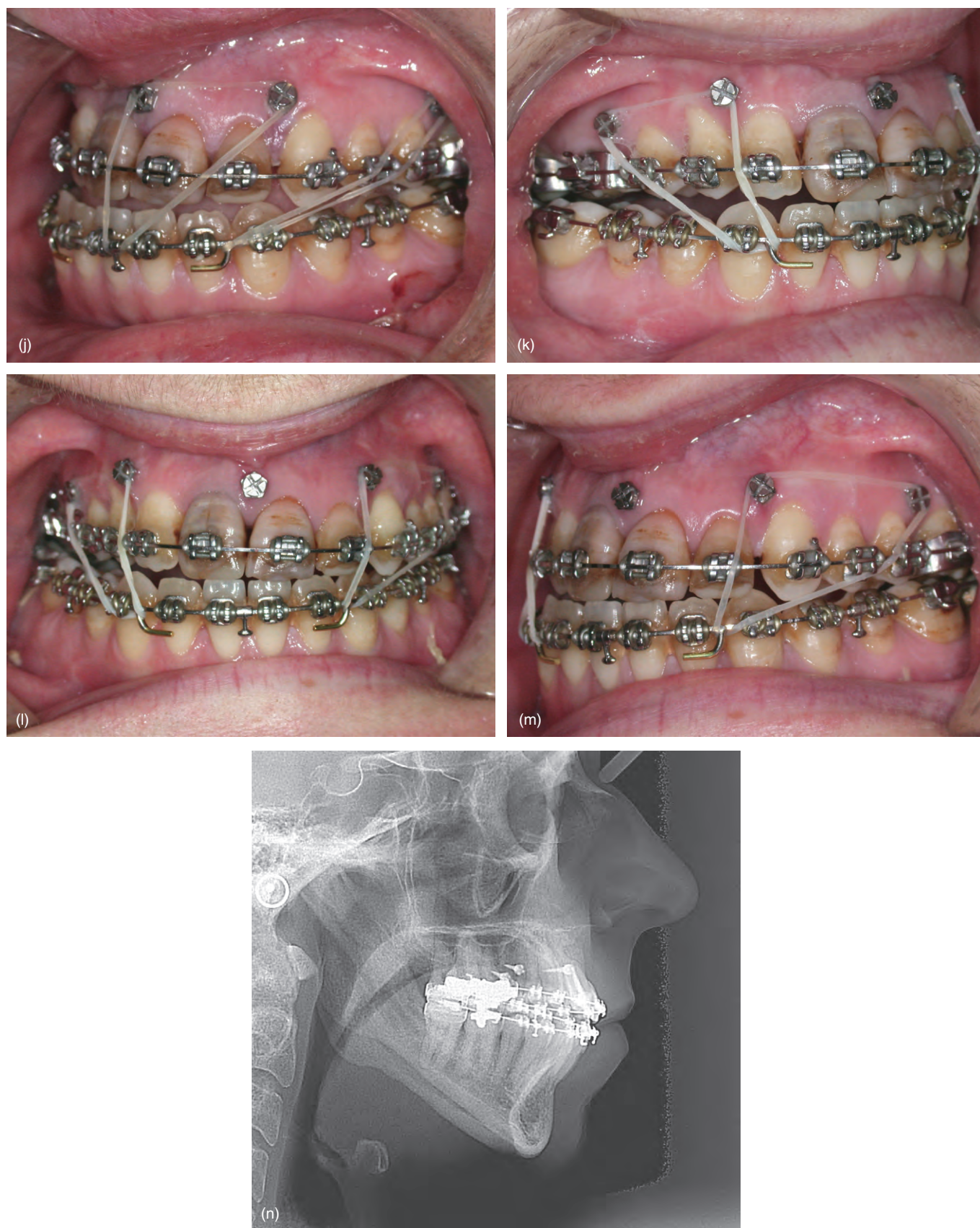


Figure 11.9 *Continued*



Figure 11.9 *Continued*

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